BULLETIN 166

# CONTRIBUTIONS TO ZOOLOGY, 1958

1959

NATIONAL MUSEUM OF CANADA
DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

CANADA

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

---

NATIONAL MUSEUM OF CANADA

Bulletin No. 166

BIOLOGICAL SERIES NO. 61

# CONTRIBUTIONS TO ZOOLOGY, 1958

Issued under the authority of
The Honourable Alvin Hamilton, P.C., M.P.
Minister of Northern Affairs and National Resources

1959

*Price, $1.00*

72281-9—1

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1960

# CONTENTS

PAGE

The fauna of Minas Basin and Minas Channel, by E. L. Bousfield and A. H. Leim 1

Some freshwater fishes from northeastern Quebec and Labrador, by D. E. McAllister and Sherman Bleakney 31

The dentition of rabbits and the origin of the Lagomorpha, by Loris S. Russell 41

Distribution of the barren ground grizzly bear in northern Canada, by A. W. F. Banfield 47

## Illustrations

Paper 1:

Figure 1. Localities visited 4

Figure 2. Surface temperatures in the Minas Basin region 6

Figure 3. Surface salinities in the Minas Basin region 9

Paper 2:

Figure 1. Map showing places visited 32

Paper 3:

Figure 1. *Sylvilagus floridanus*, unworn upper right dentition 41

Figure 2. *Sylvilagus floridanus*, unworn lower right dentition 43

Figure 3. Upper right molars of lagomorphs and possibly ancestors 45

Paper 4:

Figure 1. Barren ground grizzly bear distribution during the period between 1714 and 1899 49

Figure 2. Barren ground grizzly bear distribution during the period between 1900 and 1935 54

Figure 3. Barren ground grizzly bear distribution during the period between 1936 and 1958 56

# THE FAUNA OF MINAS BASIN AND MINAS CHANNEL

By E. L. Bousfield and A. H. Leim[1]

## Introduction

Minas Channel and Basin, including Cobequid Bay, at the upper end of the Bay of Fundy, form an unusual coastal marine habitat. The tidal amplitude of up to 53 feet is unique; it results in very thoroughly mixed water, which, because it is relatively shallow, is warmer in summer and colder in winter than that of the Bay of Fundy proper. This strong tidal mixing keeps much silt in suspension in the Basin, making for extreme turbidity and relatively little penetration of light into the surface waters. The intertidal zone is remarkable not only for its extreme vertical range, but also for its extreme horizontal range, because of gentle shore-line gradients; some beaches are more than three miles wide at low water. Reflecting these unusual physical conditions is the remarkable composition of the fish and bottom fauna. A detailed listing of the more conspicuous marine animals of the region and an inquiry into the relationship between their distribution and environments are the chief purpose of this report.

One of the authors (A.H.L.) collected material at a few points in this area in the summers of 1920 to 1922 while engaged in a study of the shad (*see* Leim, 1924). The other (E.L.B.) collected somewhat more widely during the summer of 1958. The two investigations thus provide a reasonably comprehensive picture of the marine macro-fauna of the region and afford a comparison over a period of some thirty-five years.

The early collections were made at Scotsman Bay, Nova Scotia, in August of 1920 and 1922 and at Bass River and Tennycape, N.S., in August and early September, 1921. Weir catches provided most of the fish; the invertebrates were mainly from shore collections. The Atlantic Biological Station boat *E.E. Prince* carried out hydrographical measurements and biological collecting at seven stations, numbers 190 to 196, during the first ten days of September, 1920. These stations were in Minas Channel and the lower part of Minas Basin (*see* Fig. 1). The hydrographical and biological results are given in Table 2 and in the main body of this report, respectively.

During the period June 23 to August 2, 1958, some thirty stations along the shores of the region were visited. Collections of intertidal invertebrates were made at sixteen stations, and hydrographical measurements at seven (*see* Table 1 and Fig. 1). More than 130 species of littoral marine invertebrates were obtained, of which the crustaceans and molluscs, making up 90 per cent of the total, are treated herein. Results of brief collecting trips to Economy Point, Bass River, Tennycape, and Walton, in June, 1950, are also included.

---

[1] Fisheries Research Board of Canada, Biol. Sta., St. Andrews, N.B.

## ACKNOWLEDGMENTS

The early studies were carried out under the auspices of the Biological Board of Canada and the University of Toronto. Acknowledgment for assistance in the identification of various invertebrate groups is gratefully made to specialists concerned, whose names are given in the station lists of material. The recent field work was carried out under the National Museum of Canada in co-operation with the Fisheries Research Board of Canada. Special mention is made of Dr. A. G. Huntsman for much advisory assistance and for the identification of Ascidians and Chaetognatha.

## PHYSICAL CHARACTERISTICS OF THE REGION

The region under investigation lies in the north-central part of Nova Scotia (fig. 1). Minas Channel is an S-shaped sluiceway about 30 miles in length, linking Minas Basin with the Bay of Fundy. It is 15 miles wide at the outer end in a line from Cape Chignecto to Harbourville (S13), and narrows to about 4 miles at the inner end between Cape Blomidon and Partridge Island, near Parrsboro. The total area of the Channel is 300 square miles (planimeter measurement). Because the shores are typically steep and rocky, the total intertidal area is only 5 square miles. Indentations at Advocate, Spencer's Island, Scotsman Bay, and West Bay are characterized by a hard shelving foreshore of sand and mud, usually bordered at the HW line by coarse gravel. During relatively quiet summer months, several inches of soft mud may accumulate on top of the sand but is washed away during winter storms.

Most of the Channel is between 25 and 50 meters in depth, ranging down to 100 meters in the central trough. The mean high water level in Minas Channel is approximately 10.7 meters (35 feet) above 0 datum, and the mean tidal difference is 9.1 meters (30 feet). The mean HW depth is 46 meters (126 feet) and the LW depth (0 datum) is 35.3 meters (97 feet). The speed of tidal currents at all depths in the narrow part of the Channel reaches six to eight knots. Although carried back and forth by tidal action, the water to the south of the main channel seems to be stationary over a complete tidal cycle. What is locally known as the "cedar swamp" occurs here, a miniature Sargasso Sea, in which seaweed, wreckage, and other debris collect. The material drifts back and forth with the tidal ebb and flow from near Cape Split at the inner end to a point south of Isle au Haute at the outer. Local fishermen state that this debris remains in the region until it becomes water-logged and sinks. They cite, as evidence, the case of a small wrecked vessel which drifted in this locality for months.

Minas Basin and Cobequid Bay form a triangular body of water 50 miles long and 18 miles wide at its western base. The total surface area (including estuaries) of 435 square miles is nearly half again that of the Channel. Most of the Basin is less than 25 meters in depth, except for a deeper tongue intruding from Minas Channel near the mouth. The mean depth at LW (0 datum) is 14.6 meters (48 feet). The mean rise of tide above datum is approximately 13.8 meters (45 feet), the mean intertidal difference is 11.9 meters (39 feet), and the mean depth of the Basin at HW is 20.9 meters (68.5 feet).

Ketchum *et al.* (1953) have given values for the intertidal and high-tide volumes and exchange ratios of various tidal exchange segments in Minas Channel and Basin. Thus, during ebb tide, water at the mouth of Cobequid Bay moves to a point near the mouth of the Basin. The exchange ratio in this segment (intertidal : high tide volume) is 0.6; in other words, about 60 per cent of the water mixes with the next seaward segment and does not return on the flood. The exchange ratio is extremely high in Cobequid Bay (76 to 94 per cent) but is much lower in Minas Channel (23 to 39 per cent) because of the smaller tidal amplitude and greater depth.

The intertidal zone of the entire Basin is mainly sandy mud overlying Carboniferous and Triassic sandstone. During summer, soft mud collects on the tidal flats, especially in the estuaries, to a depth of 8 to 12 inches. The entire eastern half of Cobequid Bay and the mouth of the Avon estuary is sandy mud. At extreme low water the area of the intertidal region is approximately 153 square miles, or more than one-third the total area of the Basin. No other coastal marine area in the world of comparable size has such a large proportion of bottom exposed to the air environment at low tide.

The amount of fresh water entering Minas Basin and Channel, particularly from rivers of the south side, is appreciable and supplies about 15 per cent of the total mean annual flow into the Bay of Fundy. The total area of the Minas watersheds is 3,300 square miles (Watson, 1936), or about four times the surface area of Minas Basin and Channel combined (735 square miles). During the summer months (July to Sept.) an average value of about 3,500 c.f.s.* is discharged into the Basin and Channel, more than half from the Avon and Shubenacadie watersheds. Since, however, the total drainage area relative to that of the Basin and Channel is small (approx. 4:1), the effect of the fresh water on surface salinities is likewise small. Moreover, owing to vigorous tidal mixing, surface salinities, except at the head of Cobequid Bay and in the southern bight, are typically marine rather than estuarine in character.

## HYDROGRAPHIC CONDITIONS

A striking feature of the hydrography of the region is the pronounced vertical mixing by tidal action. The results of the *Prince* expedition in the area in early September, 1920, show near-uniform temperatures (14.0-14.4°C. and salinities (31.26-31.4‰) both vertically (0-70 meters) and horizontally across Minas Channel to Scotsman Bay (Table 2). Also, at the mouth of the Basin (*Prince* 194) near-uniform temperatures (14.35-14.5°C.) and salinities (31.29-31.33‰) prevailed from surface to 45 meters. However, progressing southward into the Basin, we note significantly higher temperatures and lower salinities at all depths, and greater vertical differences, reaching 16.5°C. and 30.84‰ respectively at the surface at *Prince* 196, northeast of Kingsport. Southward extrapolation of this trend would indicate that the southern bight of Minas Basin is distinctly more estuarine in physical characteristics than the main part of the Basin.

---

* This is equivalent to an average summer value of about 1.0 c.f.s. per square mile of drainage area, which compares favourably with values calculated for the Miramichi watershed in northern New Brunswick (c.f. Bousfield, 1955a).

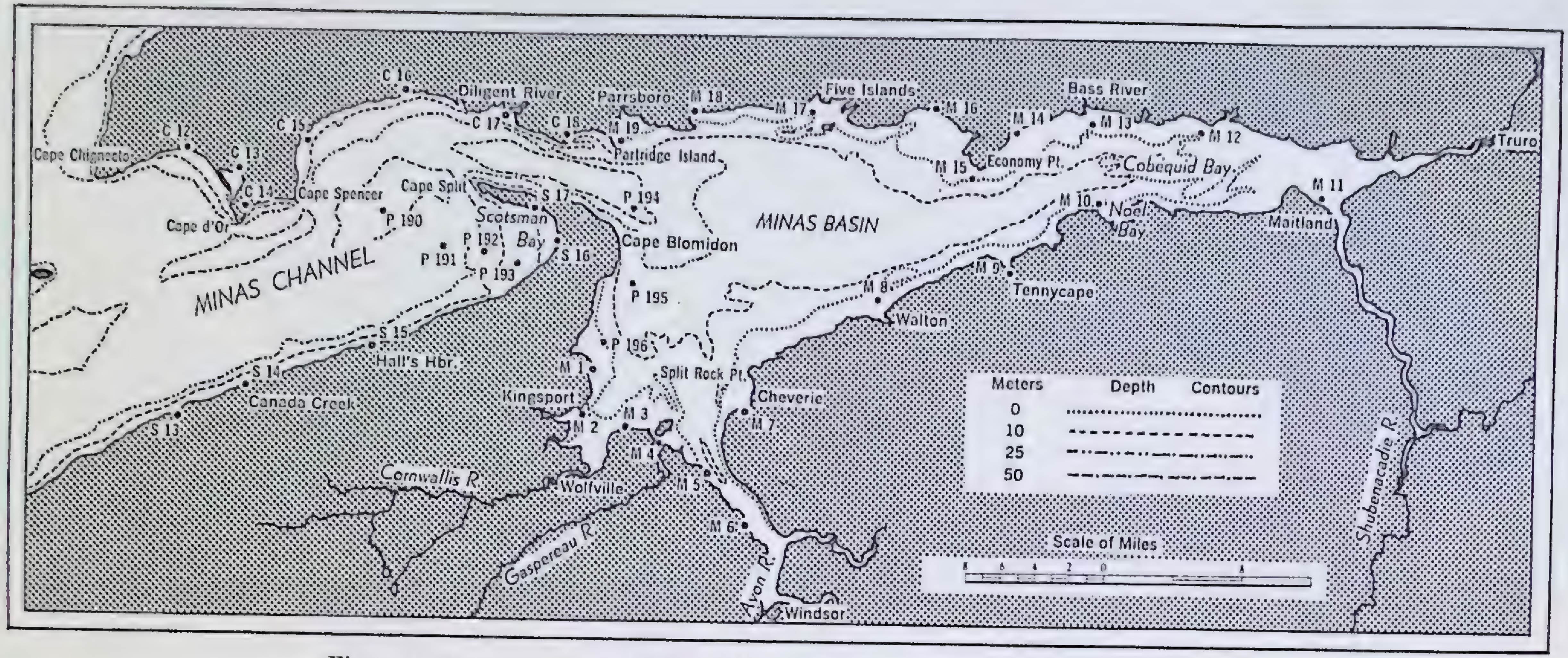


Figure 1. Localities visited in the Minas Channel – Minas Basin region, 1920-22, 1950 and 1958.

## TABLE 1. STATIONS VISITED

Key to Sta. numbers: S —South coast of Minas Channel
M—Minas Basin
C—Chignecto coast of Minas Channel

| Sta. No. | Date (1958) | Locality | Habitat | Water Temp. (°C.) | Water Sal'y. (‰) |
|---|---|---|---|---|---|
| | | KINGS CO.— | | | |
| S14 | June 27 | Canada Creek | Boulders, stones, and gravel; LW-HW levels. | 11.9 | 30.8 |
| S15 | " 27 | Hall's Harbour | Gravelly mud flats of river mouth; rock pools; MW-HW levels. | 12.0 | — |
| S16 | " 24 | Scotsman Bay | Coarse gravel beach, HW level. | — | — |
| S17 | " 24 | Scotsman Bay | Rock pools near HW level. | 18 (tide pool) | — |
| M1 | " 25 | Shore opp. Paddy I. | Sandstone cliffs, sandy mud flats; MW-HW levels. | — | — |
| M2 | " 25 | Kingsport | Sand and sandy mud flats HW-LW levels. | 22 | — |
| M3 | " 26 | Evangeline Beach | Coarse sand; mud and boulders; HW 1 level. | — | — |
| M4 | " 26 | Avonport Beach | Coarse sand, sandstone and mud; MW-HW levels. | — | — |
| M5 | " 27 | Blue Beach | Shingle and pebble beach HW level | — | — |
| | | HANTS CO.— | | | |
| M6 | " 27 | Aberdeen Beach | Coarse sand and mud, HW level | — | — |
| M7 | July 17 | Cheverie wharf | Coarse sand; HW level | — | — |
| M8 | " 17 | Walton | Shale, mud, sand; LW-HW levels | 17.5 | — |
| M9 | " 18 | Tennycape Hbr. | Sand spit; HW 1 level | — | — |
| M10 | " 18 | Burntcoat Hd., at Noel Bay | Sandstone; stones, gravel, muddy sand. LW-HW levels | 17.2 | 29.3 |
| M11 | " 19 | Maitland, N. of wharf | Mud, sand, sandstone LW-MW levels | 19.8 | 24.6 |
| | | COLCHESTER CO.— | | | |
| M12 | " 20 | Spencer Pt. | Muddy sand, sandstone; LW. | 18.5 | 27.8 |
| M13 | " 20 | Bass R., at fish weir | Pebbles, small stones, sandy mud; LW-HW levels | — | — |
| M14 | " 21 | Cove Road Beach, Economy Pt. | Steep gravel beach; MW-HW levels | — | — |
| M15 | " 21 | Economy Pt. | Sandstone boulders, sand and shells; LW-HW levels | — | — |
| M16 | Aug. 2 | Lower Economy at wharf. | Coarse sand and gravel, at HW level | — | — |
| M17 | " 2 | Lower Five Islands at at wharf and weirs | Mud, sandy mud, gravel; LW-HW levels | 18.0 | 29.6 |
| | | CUMBERLAND CO.— | | | |
| M18 | July 22 | Mouth of Swan Creek, nr. Clarke Hd. | Coarse sand and gravel at HW level | — | — |
| M19 | " 22 | Partridge I., south of Parrsboro | Rock, boulders, sand and gravel; LW-HW levels | 14.2 | 30.7 |
| C18 | " 22 | West Bay | Coarse gravel beach at HW. | — | — |
| C17 | " 23 | Diligent R. | Gravel and sand; LW-HW levels. | 14.2 | — |
| C16 | Aug. 1 | Port Greville | Course gravel beach at HW. | — | — |
| C15 | " 2 | Spencer's Island | Fine sand, gravel, boulders LW level | 13.0 | 30.9 |
| C14 | July 31 | Horseshoe Cove, nr. Cape d'Or | Coarse gravel and sand at HW | — | — |
| C13 | " 31 | Advocate Harbour | Sandy mud, stones; nr. HW. | — | — |
| C12 | " 31 | West Advocate | Gravel beach and sandstone HW level | — | — |

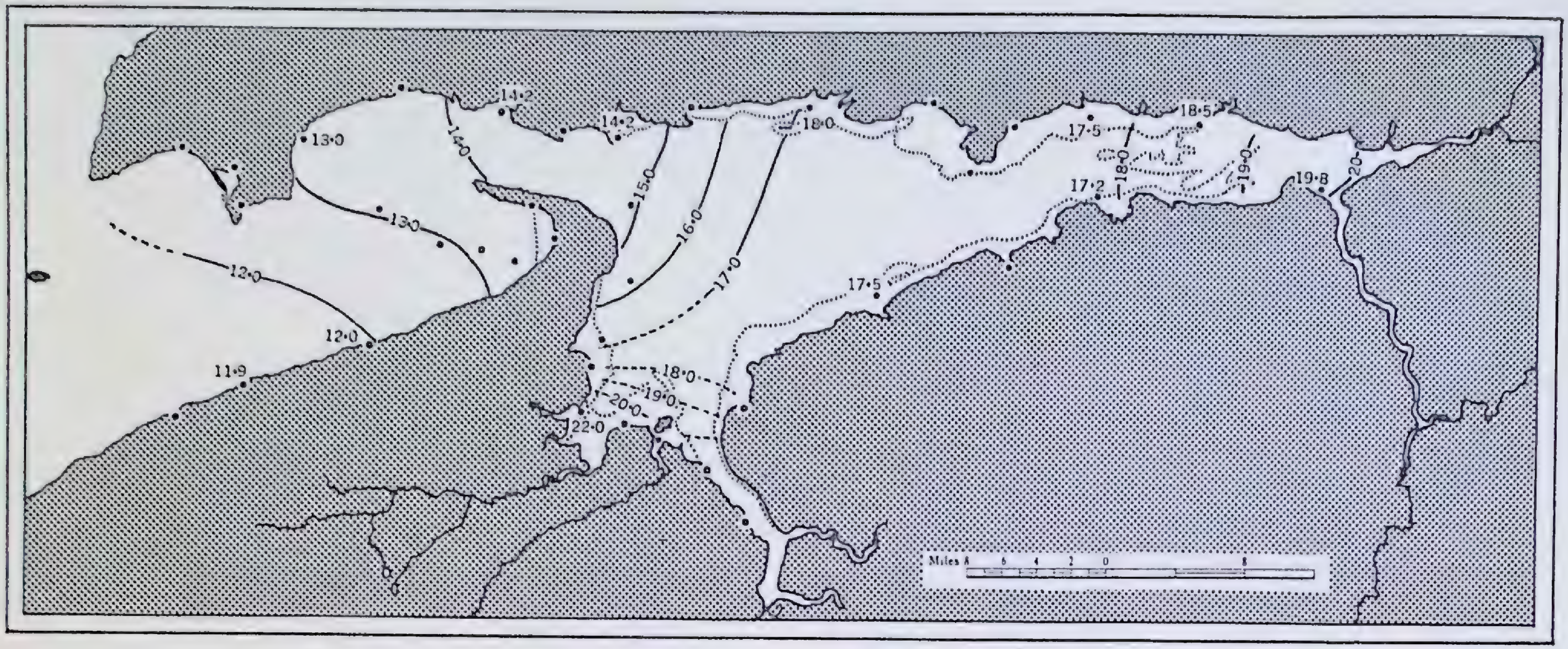


Figure 2. Surface temperatures (°C.) in the Minas Basin region, LW values, June 25 to Aug. 2, 1958.

### TABLE 2.

### Hydrographical results of the "Prince" Expedition in Minas Channel and Basin, September, 1920

| Minas Channel, Sept. 4/1920 | | | | | | | | | | | | Minas Basin, Sept. 8/1920 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P 190 8:10 a.m. | | | P 191 6:45 a.m. | | | P 192 9:55 a.m. | | | P 193 10:35 a.m. | | | P 194 8:45 a.m. | | | P 195 10:17 a.m. | | | P 196 12:36 p.m. | | |
| D. (m) | Temp. (°C.) | Sal'y. (°/₀₀) | D. (m) | Temp. (°C.) | Sal'y. (°/₀₀) | D. (m) | Temp. (°C.) | Sal'y. (°/₀₀) | D. (m) | Temp. (°C.) | Sal'y. (°/₀₀) | D. (m) | Temp. (°C.) | Sal'y. (°/₀₀) | D. (m) | Temp. (°C.) | Sal'y. (°/₀₀) | D. (m) | Temp. (°C.) | Sal'y. (°/₀₀) |
| 0 | 14.25 | 31.26 | 0 | 14.0 | 31.27 | 0 | 14.4 | 31.27 | 0 | 14.4 | 31.29 | 0 | 14.5 | 31.29 | 0 | 15.0 | 31.11 | 0 | 16.47 | 30.84 |
| 10 | " | 31.27 | 10 | 14.1 | 31.40 | 12 | 14.1 | 31.29 | 4 | 14.3 | 31.29 | 10 | 14.37 | 31.29 | 10 | 14.8 | 31.17 | 6 | 15.56 | 30.84 |
| 25 | " | 31.27 | 25 | 14.08 | 31.33 | — | — | — | — | — | — | 25 | 14.35 | 31.33 | 20 | 14.75 | 31.17 | — | — | — |
| 50 | " | 31.29 | — | — | — | — | — | — | — | — | — | 45 | 14.35 | 31.33 | — | — | — | — | — | — |
| 70 | " | 31.31 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |

The observations of the *Prince* are, in general, corroborated by measurements of temperature and salinity made at low water level at selected localities around the shores of the region during early summer of 1958 (fig. 2 and 3). Fig. 2 indicates that surface temperatures in the central Basin were between 15° and 18°C., whereas those of the southern Bight and Cobequid Bay were consistently above 17°C., reaching more than 20°C. in the Avon and Shubenacadie estuaries respectively. Here the surface waters are heated as they roll in over the extensive tidal flats that are warmed by the sun when the tide is out.

Fig. 3 suggests more or less uniformly high surface salinities (29.5-30.5‰) over the main Basin, decreasing rather sharply through the southern bight and Cobequid Bay to values of less than 25‰ in the Avon and Shubenacadie estuaries respectively. On the average, the numerical values of salinity for 1958 are about 0.5‰ lower than those at corresponding localities in 1920 owing to the fact that the former measurements were made (1) at dead low water or nearly so and thus minimal for the tidal cycle, (2) at hip-boot distance from shore and presumably under slight influence of fresh water seepage from the land, and (3) during early summer (June and July) when the effect of spring freshets was still being felt. A value of 29.01‰ taken at Bass River on August 15, 1921, is correspondingly higher than the 1958 value of about 28.5‰ predicted from fig. 3.

The extreme turbidity of the water in this region is indicated by Secchi disc values given by Huntsman (1952). The values decreased from 5.75 to 10.25 meters (20 to 35 feet) in the Bay of Fundy, through 3.00 to 3.75 meters (10 to 12 feet) in Minas Channel, down to 1.25 meters (4 feet) off Kingsport in the Basin. Shore observations in 1950 and 1958 indicate that values in the southern bight and throughout Cobequid Bay are still lower and probably average less than 0.5 meters (1.5 feet). At some collecting localities, when the hands were placed wrist-deep in the water the fingertips were not visible.

## HISTORY OF THE SEA FISHERIES OF THE REGION

Although several writers have referred to the shad and salmon of these waters, very few have given any account of the fishing methods employed. Perley (1852) seems to have given about the only information that is available. This following account is derived mainly from that source and from the evidence given before the Dominion Shad Fishery Commission (Prince, *et al.*, 1910).

The most important fishery of the area from early times seems to have been the shad. Two main methods have been employed. First, weirs either of brush or of twine ("seines") were used. These were often of great length and captured large numbers of shad and some salmon. On the north shore of Minas Basin there was an average of one weir for every mile of shore, and "between Graham's Head and Economy Point, the flats for four miles were observed to have an almost unbroken continuance of these weirs, crescent-shaped, the ends of the weirs touching each other" (Perley).

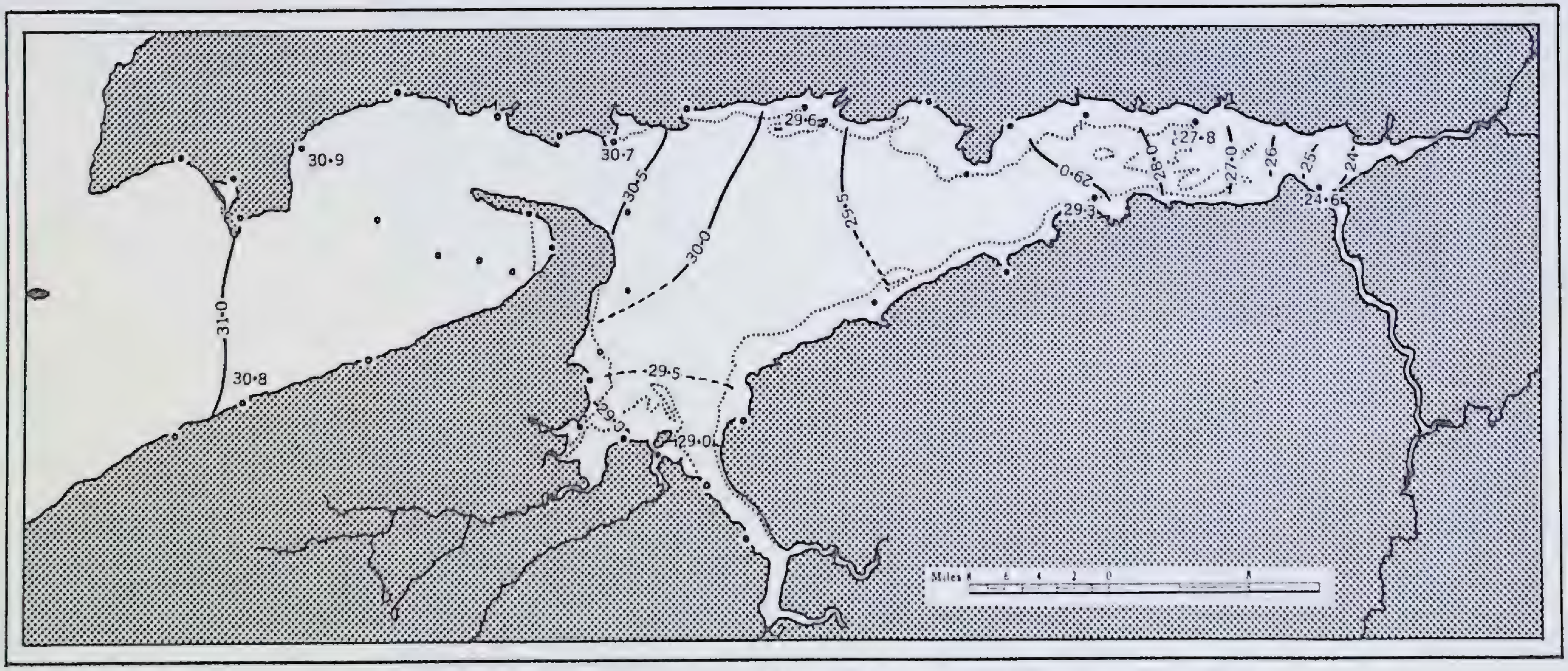


Figure 3. Surface salinities (‰) in the Minas Basin region, LW values, June 25 to Aug. 2, 1958.

Drift nets were also used in the shad and salmon fisheries. Using this method the boats put out several hundred yards of gill net in the upper part of the Basin and drifted down the ebb tide and back to the starting point with the flood. It is stated that the use of drift nets began about 1840 on the Windsor (Avon) River.

The drift net gave rise to another method of fishing, which is known as a "stake net" or "set net". Instead of allowing the nets to drift freely, they were attached to stakes driven in the mud of the intertidal zone. These were unlike the "seine" weirs in that they were set in a straight line; one is recorded at Burntcoat Head as being 3 miles long, and the fish were caught in the meshes. Shad fishing was carried on in Scotsman Bay, Minas Basin, and Cobequid Bay but not in Minas Channel.

The salmon fishery was the next most important and was carried on in the same way as the shad, that is by means of brush weirs and drift nets. Salmon were obtained in the largest quantities in the Avon River, Cobequid Bay, and Economy River. More recently, Huntsman (1958) has dealt with fluctuations in the population of salmon in the Shubenacadie estuary and Cobequid Bay.

The other fisheries were minor ones. Although gaspereau were abundant, and many were caught in weirs, there appeared to be no demand for this fish.

Some of the weirs in Minas Channel obtained fat spawning herring, and this was apparently an important fishery in a localized area. It was stated that "they deposit such quantities of spawn that it can be shovelled up upon the beach."

There was fishing for cod in Minas Channel on the north shore, from Parrsboro to Cobequid Bay, and at the mouth of the Avon. This fishery was a primitive one. Poles were driven into the flats at low tide and baited hooks attached. On the following low tide the fish were collected.

Good pollock and some haddock fishing is reported on the north shore of Minas Channel as far as Cape Sharp. Some halibut were obtained in the same locality, and large quantities of flounder were said to have been smoked at West Bay, just east of Cape Sharp.

In addition, "tons of eels," many smelt, and some large sturgeon were taken to the south of Cape Blomidon.

Some bass were obtained farther up the Basin, but even in 1850 this fishery had become an unimportant one owing to the small quantities available.

The methods of fishing described by Perley are being employed today with scarcely any change. Owing to the decline of the shad and salmon, however, there has been a very great reduction in the number of weirs and drift-net boats, and except for herring nets on the south shore opposite Isle au Haute, it is doubtful if stake nets have been set. Cod, with the exception of those taken in the weirs, are still fished by means of lines attached to stakes and set out on the flats. The cod and herring do not seem to have been included in the decline which occurred in most of the other fisheries.

## PREVIOUS COLLECTIONS IN THE REGION

Surprisingly little has been published on the marine fauna of the Minas Basin region. Whiteaves (1901) summarized the 19th century invertebrate records and listed only six species. Two of these were sponges (*Chalina oculata* Pallas and *Desmacidon palmata* (Johnston)) collected by C. W. Willmot at Five Islands in 1882, and four were molluscs (*Volsella demissus* (Dillwyn), *Astarte undata* Gould, *A. castanea* Say, and *Crepidula fornicata* L.) taken by G. T. Kennedy at various localities in 1875. Kindle (1916, 1917) reported on certain collections, mainly intertidal, which he and Whittaker made at Kingsport, near *Prince* 196, and at Cheverie Pt., on the eastern side of the mouth of the Avon estuary. The material included one species of sponge, one of annelids, five of bryozoans, twenty-nine of molluscs, two of echinoderms, and four of crustaceans. Between 1922 and the present, published references to selected invertebrates of the Minas Basin region have been made by Huntsman (1924), Johansen (1930), Bousfield (1952), and again by Huntsman (1952), this last being a comprehensive analysis of the recent status of the marine fisheries with reference to food organisms, both benthonic and planktonic, and to factors underlying the marine productivity of the basin. The Stephensons (1954) carried out a detailed ecological survey of the intertidal region at Hall's Harbour and described the vertical range of conspicuous invertebrate animals and marine algae. Finally Jermolajev (1958) described the zooplankton of the region, noting the abundance of such endemic species as *Acartia tonsa* Dana, *Eurytemora herdmani* Thompson and Scott, *Pseudodiaptomus coronatus* Williams, and a form of *Centropages hamatus* (Lillj.).

## FAUNAL LIST

### I. FISHES (Phylum CHORDATA; Class PISCES)

*Alopias vulpinus* (Bonnaterre). Thresher shark. Not seen by the author, but reliably reported from Scotsman Bay and Parrsboro.

*Squalus acanthias* Linnaeus. Spiny dogfish. Occasional in weir at Scotsman Bay. More abundant at *Prince* station 191.

*Raja laevis* Mitchill. Barndoor skate. Occasional throughout the region.

*Raja diaphanes* Mitchill. Big skate. Occurs throughout the region.

*Raja erinacea* Mitchill. Tobacco box skate. Abundant throughout the region.

*Acipenser sturio* Linnaeus. Sturgeon. Taken occasionally. A few are caught annually in the Avon River.

*Clupea harengus* Linnaeus. Herring. Common throughout the region, all sizes being represented. Spawning occurred, and fry were caught in plankton tows in Minas Channel and Basin, and at Bass River.

*Pomolobus pseudoharengus* (Wilson). and/or

*Pomolobus aestivalis* (Mitchill) Alewife. Immature specimens from 9 to 29 cm long were abundant at Bass River and Scotsman Bay. Mature fish ascend the Avon and Shubenacadie Rivers at spawning time. Whether all belong to the former species is in doubt.

*Alosa sapidissima* (Wilson). Shad. Specimens of all sizes from 17 to 60 cm in length were abundant at Scotsman Bay and Bass River. They spawn in the Shubenacadie River.

*Salmo salar* Linnaeus. Atlantic salmon. Taken at Bass River and Scotsman Bay in weirs, and in drift nets and traps throughout the Channel and Basin. There is a late summer run of spawning fish into the Shubenacadie River.

*Osmerus mordax* (Mitchill). Smelt. Mature and immature smelt occur throughout the area. They ascend the tributary rivers and streams at spawning time.

*Anguilla rostrata* (LeSueur). Eel. Moderately large specimens, up to 110 cm long, taken in weirs at Scotsman Bay and Bass River.

*Fundulus heteroclitus* (Linnaeus). Mummichog. Taken occasionally at Bass River and in the estuary of the Shubenacadie River.

*Merluccius bilinearis* (Mitchill). Silver hake. Very abundant in late summer at Scotsman Bay; less frequent at Bass River.

*Gadus callarias* Linnaeus. Cod. Infrequent in summer at Scotsman Bay and absent at Bass River. Abundant in both places in spring and autumn, when they are fished for.

*Microgadus tomcod* (Walbaum). Tomcod. Mature specimens not abundant but immature stages very abundant at Bass River, less so at Scotsman Bay. Spawns in the Shubenacadie River, where the fry are numerous in the estuary.

*Pollachius virens* (Linnaeus). Pollock. Infrequent at Scotsman Bay.

*Urophycis tenuis* (Mitchill). and/or

*Urophycis chuss* (Walbaum). Hake. Mature hake were abundant at *Prince* station 191 and smaller numbers were caught at stations 192-196. Immature sizes were abundant in the weirs at Scotsman Bay and Bass River.

*Pseudopleuronectes americanus* (Walbaum). Winter flounder. Moderately common at Scotsman Bay, Bass River, and at *Prince* stations 191-3, 195-6. Those caught at Bass River were smaller. Larvae were found at Bass River and at *Prince* stations 191 and 195.

*Liopsetta putnami* (Gill). Smooth flounder. Infrequent at Scotsman Bay; it is the most abundant flounder at Bass River.

*Lophopsetta maculata* (Mitchill). Sand flounder. Common at Scotsman Bay and Bass River.

*Menidia menidia* (Linnaeus). Silverside. Very abundant at Bass River and in the estuary of the Shubenacadie River. Taken once near Cape Blomidon.

*Syngnathus fuscus* Storer. Pipe-fish. Occasional at Bass River.

*Scomber scombrus* Linnaeus. Mackerel. An irregular visitor at Scotsman Bay; mature fish are rare, but "tinkers," 23 to 33 cm long, sometimes appear in quantity.

*Poronotus triacanthus* (Peck). Dollar-fish. Immature specimens are common at Scotsman Bay and Bass River and are caught in drift nets throughout Minas Basin.

*Roccus saxatilis* (Walbaum). Striped bass. All sizes, from 5 cm in length up, were present at Bass River; adults were infrequent, but the smaller sizes were very abundant. This species spawns in the Shubenacadie River, where its larvae are very numerous in July.

*Myoxocephalus aeneus* (Mitchill). Grubby. Taken occasionally at Scotsman Bay and at *Prince* stations 195 and 196.

*Myoxocephalus octodecimspinosus* (Mitchill). Long-horn sculpin. Occasional at Scotsman Bay and at *Prince* station 192.

*Hemitripterus americanus* (Gmelin). Sea raven. Common at Scotsman Bay. Young specimens taken at *Prince* stations 192 and 195.

*Cyclopterus lumpus* Linnaeus. Lumpfish. One small specimen was seen at Scotsman Bay.

*Ammodytes americanus* DeKay. Sand launce. Infrequent at Bass River.

*Pholis gunnellus* (Linnaeus). Rock eel. Found near Cape Blomidon and Cape Split and at *Prince* station 195.

*Macrozoarces americanus* (Bloch and Schneider). Eel pout. Found at Scotsman Bay; young individuals occurred at *Prince* stations 191, 192, and 195.

*Lophius americanus* Cuvier and Valenciennes. Angler. Frequent at Scotsman Bay.

## COLENTERATA: HYDROMEDUSAE

(Identifications of medusoids by Dr. H. B. Bigelow, Museum of Comparative Zoology, and of hydroids by Professor C. M. Fraser, University of British Columbia.)

### I. ANTHOMEDUSAE (medusoid stage)

*Podocoryne carnea* Sars. Found at *Prince* stations 195 and 196 and at Bass River.

*Nemopsis bachei* L. Agassiz. Found at Bass River. Not previously reported north of Cape Cod.

### II. ANTHOMEDUSAE (hydroid or non-medusoid stage)

*Acaulis primarius* (Stimpson). At *Prince* stations 191 and 193.
*Corymorpha pendula* Agassiz. At *Prince* station 195.
*Eudendrium tenue* Agassiz. At *Prince* stations 190, 195, and 196.
*Hydractinia echinata* (Fleming). At Scotsman Bay, intertidal.
*Tubularia spectabilis* (Agassiz). At *Prince* stations 191 and 195.
*Tubularia crocea* (Agassiz). At *Prince* station 195.

III. LEPTOMEDUSAE (hydroid stage)

*Campanularia verticillata* (Linnaeus). At *Prince* stations 194 and 196.

*Gonothyraea loveni* (Allman). At *Prince* station 196.

*Obelia dichotoma* (Linnaeus). At *Prince* station 196.

*Obelia geniculata* (Linnaeus). At *Prince* station 195; intertidal at Scotsman Bay and Bass River.

*Calycella syringa* (Linnaeus). At *Prince* stations 194 to 196.

*Halecium beani* (Johnston). At *Prince* stations 194 to 196; intertidal at Bass River

*Halecium halecinum* (Linnaeus). At *Prince* station 196; intertidal at Scotsman Bay.

*Abietinaria abietina* (Linnaeus). At *Prince* station 196.

*Diphasia fallax* (Johnston). At *Prince* stations 190, 192, 194 to 196; intertidal at Bass River.

*Diphasia rosacea* (Linnaeus). At *Prince* stations 195, 196; intertidal at Bass River.

*Hydrallmania falcata* (Linnaeus). At *Prince* stations 190, 194 to 196; intertidal at Bass River.

*Sertularella rugosa* (Linnaeus). At *Prince* stations 195.

*Sertularella tricuspidata* (Alder). At *Prince* stations 192, 195, 196; intertidal at Bass River.

*Thuiaria cupressina* (Linnaeus). At *Prince* stations 194 to 196; intertidal at Bass River.

*Thuiaria similis* (Clark). At *Prince* station 196.

*Antennularia americana Nutting.* At *Prince* station 192.

*Antennularia antennina* (Linnaeus). At *Prince* stations 195, 196.

## ANNULATA:CHAETOPODA

(Identifications by Professor A. L. Treadwell, Vassar College.)

I. POLYCHAETA:NEREIDIFORMIA

*Autolytus* sp. Taken in tows at Scotsman Bay and Bass River.

*Lepidonotus squamatus* (Linnaeus). At Prince stations 190, 192, 195, and 196, being abundant at station 195. Common on rocky shores at Scotsman Bay and found at Bass River.

*Harmothoe imbricata* (Linnaeus). At *Prince* stations 195 and 196; intertidal at Scotsman Bay and at Amethyst Cove, near Cape Blomidon.

*Phyllodoce gracilis* Verrill. Taken in large quantity at *Prince* station 195.

*Eulalia gracilis* Verrill. At *Prince* station 195.

*Nereis pelagica* Linnaeus. At *Prince* stations 190, 194 to 196, and at low water mark near Cape Blomidon.

*Nereis virens* Sars. Found under stones on mud flats at Scotsman Bay and Bass River.

*Nephthys* sp. Young specimens, thought to be *N. caeca* Gir., found on mud flats at Scotsman Bay.

*Aricia ornata* Verrill. A single specimen was found among rocks at extreme low tide at Scotsman Bay.

II. POLYCHAETA: TEREBELLIFORMIA

*Amphitrite* sp. One specimen, probably *A. attenuata* Moore, was taken at low tide on rocky bottom at Scotsman Bay.

III. POLYCHAETA:SCOLECIFORMIA

*Clymenella* sp. Found at *Prince* stations 191 and 193.
*Brada* sp. Found at *Prince* stations 191 and 193.
*Trophonia* sp. Collected at *Prince* stations 191 and 193.
*Sternaspis fossor* Stimpson. Taken at *Prince* station 191.

## ARTHROPODA:CRUSTACEA

I. CIRRIPEDIA

*Balanus balanoides* L. (Rock barnacle). Collected at M2, M8, M10, M12, M13, M17, M19, and observed on shore rocks at S16, M4, M15, and C15. Very common intertidally throughout the region but not found at the head of Cobequid Bay (M11, Maitland). On rocks, stones, shells, etc. Exuviae of this species were commonly taken in plankton tows.

*B. improvisus* Darwin (Little ivory barnacle). Collected in abundance at M2, M8, M10, M13, M15, M17, and observed at M12. A Minas Basin endemic, near and below LW level, but not taken in the Channel. On rocks, shells.

*B. crenatus* Brug. (Sharp-rimmed barnacle). Collected at M12, M17, C15, and M10, in 1950. Moderately common at and below LW level throughout the region, especially in Minas Channel and Bay of Fundy, on shells, etc.

*B. balanus* L. and *B. hameri* Ascan. Base rings of these deeper water species noted on the beach shells of *Placopecten, Volsella modiolus,* etc., from the Channel and Bay.

II. MYSIDACEA

*Mysis stenolepis* Smith. Obtained at Scotsman Bay and *Prince* 193, 195, and 196. Collected sparingly at M8 and C15 and M15 in 1950. A warmer water species usually associated with eel grass and lagoons.

*Neomysis americana* Smith. Rather more common, especially in the Basin, on sandy mud flats at M11, M12, M13, and M17, in 1950. Also taken in tows at *Prince* 190, 191, 193, 195, and 196. Partial to very low salinities (10‰).

III. CUMACEA

(Identifications of 1921 material by Dr. W. T. Calman, British Museum of Natural History.)

*Oxyurostylis smithi* Calman. Probably the most common Canadian-Atlantic intertidal species; taken at M2, M17, M19, and C15, in fine sand, at LW level.

*Eudorella truncatula* (Bate) (=*E. pusilla*). Obtained in a towing net at *Prince* stations 191, 193, 195, 196. Females made up more than 90 per cent of mature specimens.

*Diastylis sculptus* Sars. One ovigerous female taken in fine sand, LW level, at C15. Very abundant at *Prince* 191, 193, 194, and 196, of which less than one per cent were males.

*Lamprops quadriplicata* Smith. Six adult and 4 imm. specimens taken at C15 and 5 females at *Prince* 195.

*Leucon* sp. One male specimen in surface tows at *Prince* 190.

IV. ISOPODA

*Ptilanthura tenuis* Harger. One female, in fine sand, at C15. Appears to be a second Canadian record, the first being at Grand Manan (after Wallace, 1919).

*Cirolana polita* Harger. One immature specimen taken at C15. A cold-temperate species.

*Jaera marina* (Fabr.). A very common, widely distributed, intertidal species; taken at S14, S15, S17, M2, M8, M10, M12, M13, M15, M17, M19, C17, and C15; observed at S16 and at Amethyst Cove near Blomidon in 1921. There are several ecological subspecies known, of which two or more occur in Eastern Canada and are probably represented here. Males necessary for determination.

*Idothea baltica* (Pallas). A very common species, especially on fucoids, debris; common at Bass R. and Scotsman Bay and also taken at S14, M8, M15, M17, M19, C17.

*I. phosphorea* Harger. Less abundant and tending to warmer water localities than the above. Common at Bass River and Scotsman Bay, and at *Prince* 191 and 196. Immatures taken at M10, M15, C15, and adults at M13, M15 in 1950.

*Chiridotea caeca* (Say). Collected at mid-tide levels on sand beaches, especially in f.w. seeps, at M2 and M11, and M8, in 1950. A species of relatively ice-free shorelines.

*C. tuftsi* (Stimps). Far more abundant in the region than above. Taken at *Prince* 196 and at M2, M11, M12, M17, M19, and C15, in the lower tidal zone, on sand.

*Edotea montosa* (Stimps). Taken at M2, M19, and C15, burrowing in sand, and quite numerous at *Prince* 191, 193, 195, and 196.

V. AMPHIPODA

*Tmetonyx nobilis* (Stimps). A common sand-burrowing species of shore-line and shallows. Taken at M11, M15, M19, and C15; mainly immature specimens.

*Orchomenella minuta* (Kr.). Several specimens from shad stomachs.

*Hippomedon serratus* Holmes. Two immature specimens taken at C15.

*Haustorius arenarius* Slabber. Three specimens at C15, burrowing in fine sand. Taken only twice previously in Canada (Bousfield, 1956).

*Bathyporeia quoddyensis* Shoemaker. Scarce intertidally at M11 and M15. Known only from the Gulf of Maine. Taken at Bass R. in 1921 (Shoemaker, 1949).

*Ampelisca spinipes* Boeck. Rather common in sand and sandy mud at low water level throughout the Basin. Taken at M2, M8, M15, M19, and C15.

*Phoxocephalus holbolli* (Kr.). A circumpolar eurythermal species, taken in sizeable numbers at M19 and C15.

*Sympleustes glaber* (Boeck). One immature specimen taken at C15, LW level.

*Stenopleustes gracilis* Holmes. One ovig. female taken at M8 at LW. Common in the Bay of Fundy (Shoemaker, 1948).

*Calliopius laeviusculus* Kr. A very common coastal and littoral semi-pelagic species taken in numbers at M2, M8, M10, M11, M17, M19, C17, and C15.

*Pontogeneia inermis* Kr. A cold-water, free-swimming species of the lower intertidal region. Taken in the Channel at M19, C17, and C17.

*Dexamine thea* Boeck. Two specimens taken at C15. Likewise a cold-temperate species.

*Gammarellus angulosus* (Rathke). A species indicating uniformly cold-temperate and relatively clear waters of surf-exposed rocky coasts. Reaches the Channel only at S14, among algae at LW level.

*Gammarus oceanicus* Segerstrale. The most common intertidal amphipod; widely eurythermal and euryhaline; a summer breeder in Minas Basin. Taken at S14, S15, S16, M2, M8, M10, M11, M12, M13, M15, M17, M19, C17, and C15. Formerly known in America as *G. locusta* L. and *G. ornatus* M.-E.

*G. setosus* Dement. Two specimens taken in Scotsman Bay by A.H.L. in 1921, on shore. An arctic-boreal species not abundant in the Gulf of Maine.

*G. lawrencianus* Bousfield. A very common estuarine and intertidal species. Taken abundantly throughout the region; S14, S15, M2, M8, M11, M17, M19, and C17. Formerly known as *G. annulatus* in the Canadian Atlantic region.

*G. tigrinus* Sexton. A species of low-brackish tidal pools and headwaters of estuaries. Taken at S15, M8, M17 and observed at M6 and M7. Dominant in the Shubenacadie and Avon estuaries. (Formerly identified as *G. fasciatus* Say.)

*G. mucronatus* Say. A species of warm-water estuaries and saltmarsh pools. Restricted to and rather uncommon in Minas Basin; taken in the estuary at Five Islands (M17).

*Rivulogammarus duebeni* (Lillj.). Common in rock pools near HW level of wave-exposed coasts. Taken at S14, S15, and S17, but not inside the Basin.

*Marinogammarus obtusatus* Dahl. Taken at S14, S15, and M15, under stones and pebbles about mid-tide level, especially where free water trickles down the beach.

*M. finmarchicus* Dahl. Taken in tidal pools and under stones mainly near the top of the *Fucus* and barnacle zone, in the Bay and Channel at S14, S15, S17, M19 and C17, but not in the Basin proper.

*M. stoerensis* Reid. Taken near LW level at the mouth of streams tumbling down stony beaches, at S14 and C17, but not inside the Basin.

*Melita dentata* (Kr.). Taken in the Channel at C17 and C15, LW level.

*Hyale nilssoni* (Rathke). Under fucoids on rocks, etc., mid-tide level, at S14, S17, M8, M10, M13, M15, C15, and observed at C14.

*Orchestia platensis* (Kr.). The common beach flea of the entire region. Collected under wave-cast debris at the HW line at S15, M12, M15, and noted nearly everywhere else.

*O. grillus* Bosc. The salt-marsh hopper, rather common in the Basin, and collected at M2 and M10, among roots of salt marsh grasses at HW level.

*O. gammarella* (Pallas). Collected at the base of a rocky cliff at M15. A species of relatively ice-free coastlines and mild winters but rather unexpected so far up the Bay of Fundy.

*Talorchestia longicornis* (Say). The common sandhopper, taken on small sand beaches at M2, M4, M9, M10, all inside the Basin, but not seen along the north shore. Not previously recorded within the Bay of Fundy (Bousfield, 1958a).

*Photis reinhardi* (Kr.). Specimens noted in shad stomachs at Scotsman Bay (Shoemaker det.).

*Amphithoe rubricata* (Mont.). Taken sparingly under fucoids at S14, M8, M15, and M19.

*Ischyrocerus anguipes* (Kr.). Taken at S17, M19, and C15. A cold-water species of the lower tidal zone, under rocks.

*Jassa falcata* Montagu. Taken at C15. Habitat similar to preceding species but preferring somewhat warmer waters.

*Leptocheirus pinguis* (Stimpson). Sparingly taken on sand bottoms at M2, C17, and C15.

*Corophium bonelli* (M.-E.). Five ovig. females taken at C15. A cold-water littoral species reaching only to the mouth of the Channel.

*Corophium volutator* (Pallas). A dominant intertidal species of mud and sandy-mud bottoms, taken at M2, M8, M10, M11, M15, M17, and C17, and observed throughout the Basin. First recorded here by Kindle (1916) and later by Shoemaker (1947).

*Corophium tuberculatum* Shoemaker. A male and ovig. female were collected at LW level at M10; apparently a first Canadian record of this southern species (c.f. Shoemaker, 1947).

*Unciola irrorata* Say. Not uncommon on sand bottoms throughout the region; taken at M8, M10, and C15.

*Caprella septentrionalis* L. Taken at M19 and C15. A cold-water species of the Bay of Fundy reaching to the Channel.

## VI. DECAPODA

*Eualus pusiolus* Kr. Three specimens collected at LW level at C15 and a single ovigerous female in a rock pool in Scotsman Bay.

*Crago septemspinosus* (Say). The common sand shrimp of the entire region. Obtained in large numbers at *Prince* 190, 191, 192, 193, 195, 196. Very abundant at M2, M8, M10, M12, M15, M17, M19 (also C15 and M13 in 1950), but uncommon in the Bay of Fundy owing to unsuitable rocky coastline.

*Homarus americanus* M.-E. Evidence of lobster fishing activities noted along the Channel at S14, S16, S17, C14, and C15, but not inside the Basin. Taken only occasionally in the weir at Scotsman Bay.

*Pagurus acadianus* Benedict. One specimen taken at M19, in an old shell of *Buccinum*. Obtained at medium depth stations in the Channel and Basin but not in the very deepest localities at *Prince* 190 and 194.

*P. longicarpus* Say. Abundant at Scotsman Bay and at *Prince* 195, 196. Also collected abundantly at M2, M8, M10, M12, M13, M15, and M17 and observed commonly in the lower part of the tidal zone throughout the Basin. Utilizes all small gastropod shells, especially those of *Urosalpinx, Thais, Littorina* and *Lunatia*. Another Basin endemic, more recently recorded in Canada from Pubnico Harbour, western Nova Scotia (Bousfield, 1958b).

*Cancer irroratus* Say. The rock crab occurs sparingly throughout the region except near the head of Cobequid Bay. Taken at M2, M10, M19 and C17, and M13 and M15 in 1950.

*C. borealis* Stimpson. The Jonah crab is common in the Bay of Fundy and reaches the Channel but not the Basin. A cold-water species, often taken in lobster pots.

*Carcinides maenas* (L.). The green crab occurs throughout the region although not taken in 1921, 1950, nor known here prior to about 1953. Collected at S14, S15, S17, M2, M10, M13, M15, M17, M19, C17, and C15.

*Ovalipes ocellatus* (Herbst). Collected at Bass River and Scotsman Bay in 1922 for the first Canadian record and subsequently included by Rathbun (1929). Female lady crabs were taken in weirs at Bass River (M13) and Diligent River (C17), and a single large cheliped was found on the beach at Kingsport (M2). A warm-water Basin endemic.

*Libinia emarginata* Leach. Taken in the weir at Bass River (M13) and noted on shore at M10. A "southern" species of muddy estuaries, first recorded from Minas Basin by Kindle (1917).

*Hyas coarctatus* Leach. One specimen, 12 mm in length, was taken in a rock pool at low-water mark in Scotsman Bay and two specimens about 3 cm in length were dredged at *Prince* 195.

## ARTHROPODA: ARACHNIDA

### I. PYCNOGONIDA

(Identifications by Professor L. J. Cole, University of Wisconsin.)

*Nymphon rubrum* Hodge. Several specimens were obtained at *Prince* 193, 195, and 196.

*Phoxichilidium femoratum* (Rathke). Taken at *Prince* 191 and 195.

*Pycnogonum littorale* (Strom). Three specimens were dredged at *Prince* 190, and a single specimen was taken intertidally at Bass River.

## MOLLUSCA

(Previous distribution according to LaRocque, 1953, nomenclature acc. to Abbott, 1954)

### I. GASTROPODA

*Acmaea testudinalis* (L). Tortoise-shell limpet. Common intertidally throughout the region. Collected on rocks at S14, M10, M12, M19, C18, and C17, and at M13 and M15 in 1950.

*Puncturella noachina* (L.). One beach specimen only, taken at M19.

*Margarites cinereus* Couth. One beach shell taken at M19.

*M. helicinus* (Fabr.). Five specimens taken at S14; larval and juvenile shells at *Prince* 191 and Bass River. A cold water species of the lower tidal zone, not populating the Basin.

*Skenea planorbis* (Fabr.). One specimen at M15.

*Lacuna vincta* (Montagu). Taken in small numbers at S14, M8, M15, M19, and C17. A cold-temperate species of outer rocky beaches. Larval specimens, probably of this species, were obtained in tows at Bass River and *Prince* 191.

*Littorina littorea* L. The common or edible periwinkle of the entire region. Small specimens were sparingly taken at Scotsman Bay, Bass River, and Tennycape in 1921; collected or observed at virtually every station visited in 1958.

*L. saxatilis* Olivi. The rough periwinkle is commonly observed in the upper tidal zone of the Bay of Fundy and Minas Channel and throughout the tidal zone in Cobequid Bay.

*L. obtusata* L. The smooth periwinkle was collected sparingly at S14, M2, and M19, and observed on fucoids at M8, M10, M15, and C15; a single specimen inhabited by *Pagurus longicarpus* was taken at Tennycape in 1921.

*Cingula aculeus* Gould. Three specimens at C15. Four juvenile shells taken in a tow at Bass River.

*Hydrobia minuta* (Totten). A common salt-marsh species, taken at M2 and M17.

*Crucibulum striatum* (Say). Four specimens taken at LW level at M19, some on *Astarte castanea,* and others at *Prince* 191, 194, and 195.

*Crepidula fornicata* L. The common slipper limpet, widely distributed throughout the Basin and Channel but not in the Bay of Fundy. Collected at M2, M8, M10, M13, M17, C18, C17, and observed as a beach shell at nearly every other station. Also taken at *Prince* 195.

*C. plana* Say. The flat slipper limpet is less widely distributed but more abundant in Cobequid Bay than the above. Taken at *Prince* 192, 195, and 196, and at M2, M8, M15, M19, and C18. Commonly lining the inner wall of *Lunatia heros*, in which hermit crabs were also living.

*Velutina laevigata* (L.). Single specimens were taken at *Prince* 194, 195.

*Polinices immaculata* Totten. This small moon snail was represented by single specimens at M2 and M19.

*Lunatia heros* (Say). The common moon shell occurs throughout the region especially on sand bottoms; collected at M2, M10, M13, M15, M19, C18, and observed as beach shells elsewhere.

*L. triseriata* (Say). The three-lined moon snail is likewise very common intertidally throughout the Basin and the shell is utilized frequently by the hermit crab. Taken at Bass River, Scotsman Bay, *Prince* 192, 195, 196, and at M2, M8, M10, M12, M13, M15, M19, and C17.

*Urosalpinx cinerea* (Say). The oyster drill is one of the most common and conspicuous shells of the lower intertidal zone of Minas Basin and Cobequid Bay where it preys largely on barnacles and small bivalves. Collected at M8, M10, M12, M13, M15, and a beach shell at C18. A warm-water Basin endemic.

*Thais lapillus* L. The common dogwinkle occurs intertidally throughout the region except at the head of Cobequid Bay.

*T. l. imbricatus* Lamarck. This fluted variety was taken only in Minas Basin, at M2, M8, M10, M13, and M17; particularly common at Bass River.

*Mitrella lunata* (Say). Rather common near low water level throughout the Basin. Collected at M2, M8, M10, M11, M12, M15, and M17.

*Buccinum undatum* L. A cold-temperate species penetrating into Minas Basin from the Bay of Fundy. Taken at all *Prince* stations except P193; also at M8, M13, M19, C18, C17, and noted as a beach shell at stations along Minas Channel.

*Colus stimpsoni* (Mörch). As above; taken at C18, noted at C14.

*C. pygmaeus* (Gould). A beach shell, collected at C18.

*Neptunea decemcostata* (Say). A common beach shell of the Channel; taken at Scotsman Bay and at C18, C17; noted at C12, C14.

*Nassarius trivittatus* (Say). The channelled basket is a common beach shell throughout the Basin and was taken in every collection. Larval specimens taken in a tow at *Prince* 191.

*Nassarius obsoletus* (Say). The mud snail is a common intertidal species of the entire Basin; collected at *Prince* 192, 195, at Bass River, and at M2, M8, M10, M11, M12; partial to warm brackish water.

*Lora nobilis* Möller. Collected sparingly at M2, M8, and M19, sometimes inhabited by *Pagurus longicarpus*.

*Lora bicarinata* (Couthouy). Taken at LW level at M2, M17, and C15, often inhabited by *Pagurus longicarpus.*

*Retusa pertenuis* (Mighels). One specimen taken at C15, in sand, at LW level.

*Cylichna alba* (Brown). One specimen at C15, as above. Taken at *Prince* 191 and 193.

*Odostomia trifida* (Totten). Four specimens, under stones, intertidal, at M10.

*O. bisuturalis* (Say). Single specimens intertidally at M10, M17.

*Turbonilla interrupta* (Totten). Common near LW line of tidal flats at M2, M7, and M8. These last three species are warm-water Basin endemics.

*Cepea hortensis* Müller. Collected along shore at M6, M19.

II. Amphineura

*Ischnochiton ruber* (L.). Single specimens under rocks at LW at M19, C15. A cold-water species penetrating into Minas Channel from the Bay.

*Ischnochiton albus* L. Three examples were dredged at *Prince* 190.

III. Pelecypoda

*Nucula proxima* Say. The Atlantic nut clam was collected at M17 and M19 in sand at LW. Larval shells, presumably of this species, were taken at *Prince* 191, 193, 195.

Arcidae. Three separated valves were taken on the beach at M19. Possibly a fossil species eroded from bottom strata.

*Crenella glandula* Totten. Taken in fine sand at LW level, at M19, C15.

*Volsella modiolus* L. A cold-water sub-tidal species extending into the Basin from the Bay. A common beach shell nearly everywhere; taken at all *Prince* stations and at M2, M13, M19, C18.

*Mytilus edulis* L. The blue mussel is remarkably scarce in Minas Basin; no mussel beds were seen anywhere in the region. Isolated specimens taken at S14, M2, M10, M19, and M15 in 1950, and noted on the beach at M8, M12, M13, and C12. A few were dredged at *Prince* 190.

*Musculus niger* Gray. Separated valves taken along shore at M8, M19, and a single juvenile at Cape Blomidon.

*M. laevigatus* (Gray). Common at *Prince* 191, 194, 195, 196.

*M. discors* L. Collected at M8; isolated valves on beach at M17, M19.

*M. corrugatus* (Stimpson). Not uncommon at *Prince* 190, 191, 194, and 195.

*Chlamys islandicus* Müller. A single valve noted at LW at M15.

*Placopecten magellanicus* (Gmelin). Beach shells taken or observed at M19, C17, C13, C12, and dredged at *Prince* 191 and 192. Both scallop species are common in the Bay and are probably washed into the Channel and Basin by the strong deep currents.

*Anomia aculeata* Gmelin. Smooth form taken at the mouth of the Avon River, opposite Cheverie Pt., and at Scotsman Bay. One imm. specimen taken at C15 and separated valves (one of the smooth form) noted on the beach at M15, M19.

*Astarte subequilatera* Sowerby. One live specimen and dead valves taken at *Prince* 194.

*A. undata* Gould. A common beach shell of the Channel; taken at M19, C17, C15, and noted at C13. Dredged at *Prince* 191, 192, 195 and collected intertidally at Scotsman Bay.

*A. castanea* Say. The dominant beach shell at M19 (also taken alive at LW, on sandy mud) and noted at C17.

*Venericardia borealis* (Conrad). A moderately common beach shell along the Channel; taken off Kingsport and at M19, C17, C15, and noted at C13.

*Arctica islandica* (L.). Two specimens and two valves at *Prince* 192.

*Cerastoderma pinnulatum* (Conrad). Isolated valves taken in sand at M19 and C15.

Veneridae? Eight isolated valves of this strongly sculptured clam (one bored by a whelk) were collected on the beach at M19.

*Pitar morrhuana* (Linsley). From 1½ miles NE. of Kingsport to shore. A single valve was taken in the lower tidal zone at M2. A warm-temperate species and a Basin endemic.

*Gemma gemma* Totten. A species of warm-water salt-marsh pools and estuaries. Taken in sandy mud at M2 and noted at M12.

*Petricola pholadiformis* Lamarck. A characteristic and dominant rock-boring species of the lower tidal zone throughout the Basin. Abundant at Bass River and collected at M2, M8, M10, M11, M12, M15, M17, and M19.

*Macoma balthica* (L.). A common species of mud flats and estuaries, extending into nearly fresh water, throughout the region. Taken at M2, M8, M10, M11, M12, M13, M17, M19, C18, C17, and noted on the beach at M7, M15, and M18. Larval shells obtained in tows at *Prince* 191 and 193. Very common in the Shubenacadie and Avon estuaries.

*Ensis directus* (Conrad). The Atlantic razor clam was taken sparingly on sand flats at M2, M10, M13, M19, and C15, larval shells at *Prince* 193.

*Spisula solidissima* (Dillwyn). Separated valves taken at M2, M19, and noted on the beach at M8, M10, M13.

*Hiatella arctica* (L.). Two juvenile specimens were dredged at *Prince* 190. A single valve was noted on the beach at M10.

*Mya arenaria* L. The soft-shell clam is moderately common on mud and sandy mud flats throughout the region. Taken at every collecting locality in the Basin and noted as a beach shell nearly everywhere else.

*Barnea truncata* Say. The fallen angel wing was not uncommon at M10, M12, and noted at M13 (Cobequid Bay), boring in sandstone at the LW level with *Petricola*, but not nearly so abundant. A warm-water Basin endemic and first Canadian record.

*Teredo navalis* L. Water-logged wood and timbers, riddled presumably by this species, were noted in the drift line along the Channel and outer Basin; may have been carried in from the Bay of Fundy.

*Lyonsia hyalina* (Conrad). Collected rather commonly on sandy bottoms at LW level at M2, M8, M10, M17, M19, and observed at C17. More than thirty specimens taken at *Prince* 195. A southward-ranging species and Basin endemic.

*Pandora gouldiana* Dall. Not uncommon in the lower tidal zone of sandy mud beaches in the Basin. Taken at M8, M10, and M19.

*Periploma leanum* (Conrad). Not uncommon in sand at LW level at M19 and C15. A single valve taken on the beach at M17.

*Elliptio complanatus* (Dillw.). Three pairs of unseparated valves were found near LW level on the beach at M19. This fresh-water species may have been ice-rafted from local estuaries.

### IV. Cephalopoda

*Loligo pealei* LeSueur. Three specimens of the long-finned squid were taken in the weir at Bass R., June, 1950. An unusual Basin endemic, taken frequently in weirs at Scotsman Bay and Bass River in 1921, and forming the basis of Huntsman's (1924) record.

## CHAETOGNATHA

*Sagitta elegans* Verrill. Found in plankton tows at *Prince* stations 191 and 195 and at Bass River.

## ECHINODERMATA

(Identifications by Mr. A. H. Clark, United States National Museum)

Echinoderms are extremely rare on the foreshore of the region. Most of the species reported below were dredged.

*Asterias vulgaris* (Packard). One specimen from each of *Prince* stations 190 and 195 and on sand bottom at C15. Recorded 1½ miles northeast of Kingsport by Kindle.

*Leptasterias littoralis* (Stimpson). Small specimens were taken at all *Prince* stations 190 to 196, and a small one, 2 cm in diameter, was collected in the intertidal zone at Scotsman Bay.

*Henricia sanguinolenta* (O. F. Müller). At *Prince* stations 191, 192, 195, and 196. Reported 1½ miles northeast of Kingsport by Kindle.

*Amphipholis squamata* (Delle Chiaje). At *Prince* stations 191 and 195.

*Strongylocentrotus drobachiensis* (O. F. Müller). A very small specimen, 17 mm in diameter, at *Prince* station 191.

*Echinarachnius parma* (Lamarck). One small specimen, 17 mm in diameter, at *Prince* station 192.

## BRYOZOA

*Flustra foliacea* (L). A very common beach shell, often washed ashore in heaps and frequently attached to *Volsella modiolus* and other bivalves. Occurs in dichotomously branching clumps of 3 to 8 inches in height.

## BRACHIOPODA

(Identification by Dr. W. H. Dall, United States National Museum.)

*Terebratulina septentrionalis* (Couthouy). Abundant at *Prince* station 191 and found at 192 and 195.

## TUNICATA

(Identifications by Dr. A. G. Huntsman, University of Toronto.)

*Molgula citrina* Ald. and Han. Two specimens at *Prince* stations 190 to 196.

*Boltenia ovifera* (Linnaeus). Sea potato. Taken at *Prince* stations 190 to 196.

*Boltenia echinata hirsuta* (Ag.) Two specimens at *Prince* station 191.

*Amaroucium glabrum* Verrill. Many large colonies at *Prince* station 195 and smaller ones at station 196.

## HYDROGRAPHIC AND MARINE BIOLOGICAL FEATURES OF THE AREA

On the basis of measurements and observations at shore localities in 1958, the study area may be separated hydrographically into three main regions, viz:

(1) Bay of Fundy, characterized by summer surface temperatures of less than 13°C., shore salinities of more than 31‰, relatively clear water (Secchi Disc depth approx. 15 to 30 feet), strong wave and surf action, but lowest tides (38 feet extreme rise of tide at HW springs).

(2) Minas Channel, characterized by geographically and bathymetrically uniform temperatures (13 to 15°C.) and shore salinities (30.5 to 30.9‰), rather turbid water (S. D. depth approx. 10 feet), reduced wave and surf action, and intermediate tides (45 feet extreme rise).

(3) Minas Basin, characterized by surface temperatures in excess of 15°C. and shore salinities less that 30.5‰, "lake-like" wave action and no surf, extremely turbid water (S. D. depth less than five feet), and highest tides (extreme rise of 53.3 feet at Burntcoat Head).

Minas Basin branches eastward and southward into two hydrographically and biologically distinct subregions, i.e., Cobequid Bay and the southern bight formed by the confluence of the Avon, Gaspereau, and Cornwallis estuaries, respectively. Because of influx of warm fresh water from the

Shubenacadie and Avon River systems and etxensive solar heating of exposed tidal flats, these two subregions are consistently warmer (17 to 20+°C.) and less salt (24 to 30‰) than the rest of the Basin and compare in these respects with other warm-brackish regions of the Bay of Fundy such as the St. John estuary, head of Chignecto Bay, and head of St. Mary Bay. The nearly land-locked situation of these two subregions and the dynamically stable circulation of the Basin are important factors in maintaining these conditions throughout the summer.

Accompanying these unusual hydrographic conditions is found a high proportion of endemic populations of animals whose normal geographic range is to the south of the Bay of Fundy or in the warm, brackish, southwest portion of the Gulf of St. Lawrence. Some of these endemic species appear to be separated from the nearest outside populations by distances beyond the normal range of larval transport; e.g. the medusa (*Nemopsis bachei*), the little ivory barnacle (*Balanus improvisus*), hermit crab (*Pagurus longicarpus*), lady crab (*Ovalipes ocellatus*), common spider crab (*Libinia emarginata*), flat slipper limpet (*Crepidula plana*), lunar dove shell (*Mitrella lunata*), pyramidellid snails (*Odostomia* spp., *Turbonilla interrupta*), rock-boring bivalves (*Petricola pholadiformis, Barnea truncata*), morrhuana Venus (*Pitar morrhuana*), and ribbed mussel (*Volsella demissus*). Huntsman (1952) listed the copepod species *Acartia tonsa* and *Pseudodiaptomus coronatus* among the holoplanktonic endemics, and Jermolajev (1958) added *Eurytemora herdmani* and a form of *Centropages hamatus.*

Certain species endemic to Minas Basin are also known from other "warm-water" but isolated localities in the Bay of Fundy region and elsewhere on the Canadian Atlantic Coast. These include the mysid shrimps *Neomysis americana* and *Mysis stenolepis,* a number of amphipods such as *Gammarus mucronatus, Orchestia grillus,* and *Talorchestia longicornis,* and tube-dwelling *Corophium volutator* and *C. tuberculatum,* the long-finned squid *Loligo pealei,* the slipper limpet *Crepidula fornicata,* the three-lined moon snail *Lunatia triseriata,* the oyster drill *Urosalpinx cinerea,* the mud snail *Nassarius obsoletus,* the bivalves *Gemma gemma, Lyonsia hyalina,* and *Pandora gouldiana,* and the sand flounder *Lophopsetta maculata.*

The maintenance of holo- and mero-planktonic populations in Minas Basin appears rather remarkable. Ketchum *et al.* (1953) point out that tidal exchange ratios of various parts of an estuary may be used to predict the distribution of free-floating or planktonic organisms in much the same manner as the distribution of fresh water in the estuary. As a result of circulation alone, the population of planktonic animals "$P_m$" remaining after being depleted from its initial size "$P_o$" by a series of tidal cycles and not receiving recruitments from upstream or downstream during the interval is given by

$$P_m = P_o\ (1-r)^m$$

in which "m" is the number of tidal cycles and "r" is the exchange ratio, defined as the proportion of water moving seaward during each tidal cycle which does not return on the following flood. Using this equation and on these assumptions, Bousfield (1955b) calculated that an exchange ratio of 0.15 in the Miramichi estuary would be sufficiently high to prevent the maintenance of *Balanus improvisus* having a fecundity of 10,000 larvae per adult and a planktonic duration of 18 days or 36 tidal cycles, at prevailing sea temperatures of 20°C. Within this estuary, a river-induced non-tidal drift, seawards at the surface and landwards near the bottom, in conjunction with changing vertical distribution of successive larval stages provided the mechanism necessary for larval retention and maintenance of the population of barnacles and other organisms.

In Minas Basin, however, the exchange ratios in 4½ tidal segments estimated by Ketchum *et al.* (1953) are theoretically much larger (0.39 to 0.94), and a residual two-layered drift circulation is virtually non-existent because of the relatively small fresh-water influx and intense tidal mixing (p. 3). Planktonic retention of many organisms within the Basin would thus appear unlikely under the conditions stated and assumptions made. How then do we account for the fact that the previously mentioned species do maintain sizeable populations well within Minas Basin?

The solution to this problem is indicated by the "Sargasso Sea" effect observed in Minas Channel (p. 2). The proper application of the simplified tidal exchange equation requires that the water flowing out of the Basin and mixing with outside waters on the ebb does not return on the flood. Owing to the trough-like configuration of the Bay of Fundy and Minas Channel there are no sustained cross-currents to carry the ebb water laterally away from the mouth of the channel. Moreover, the landward set of tidal currents along the south shore of the Bay of Fundy, under the Coriolis effect, accentuates the "bottling up" of Minas waters. Thus, virtually the same water, albeit thoroughly mixed vertically, returns on the flood: the tidal cycle creates a simple back-and-forth flow of the entire water column within the confines of the Channel and Basin. Also, the relatively small influx of fresh water results in a small net seaward flow from the Basin into the Bay. Thus larvae spawned in the headwaters remain largely within the Basin until completion of plantonic development.

Strong vertical mixing by the tides maintains a high degree of turbulence and water turbidity in Minas Basin, thereby seriously reducing the surface zone of photosynthetic activity and preventing extensive development of phytoplankton. Huntsman (1952), however, noted very large populations of endemic copepods available as food for fishes toward the head of Cobequid Bay and in the Shubenacadie estuary. He postulated that the amount of growth of the phytoplankton, on which the zooplankton feed, should increase in the headwaters of the Basin, since the shallower the water the less far they will be taken from the surface by the turbulence. Presumably then, food material for fishes and benthonic invertebrates in the Basin is derived very largely from endemic phyto- and zoo-plankton in the headwater estuaries and to a lesser extent from organisms and organic debris brought in from the Bay of Fundy by tidal mixing.

It is not surprising, therefore, to find among the most conspicuous and abundant bottom invertebrates many detritus or deposit feeders (e.g. cumaceans, mysid shrimps, burrowing amphipods (*Ampelisca, Bathyporeia, Corophium, Unciola*) and isopods (*Chiridotea, Edotea*) and bivalves (*Macoma balthica, Lyonsia hyalina*)); scavengers (e.g. *Crago, Pagurus, Cancer, Libinia,* and gammarid amphipods); ecto-parasites (pyramidellid snails);

and predators (e.g. *Urosalpinx, Thais, Lunatia, Loligo, Ovalipes, Carcinides,* and nereid worms). Many suspension or filter-feeding intertidal animals that might otherwise be expected in the Basin are relatively scarce (e.g. *Mytilis edulis, Volsella demissus, Pitar morrhuana, Teredo*) or lacking altogether (e.g. *Crassostrea virginica, Venus mercenaria, Mulinia lateralis*), although a few are abundant (e.g. *Mya arenaria, Petricola pholadiformis, Crepidula* spp., and *Balanus* spp.). The scarcity of intertidal echinoderms, despite the high salinity, is a noteworthy peculiarity of the region, which may be related to the scarcity of principal food organisms (e.g. *Mytilus*), lack of suitable cover, inability of the larvae to survive in the Basin, or other unknown factors. The absence of eel grass (*Zostera marina* L.) and its associated microflora and fauna (e.g. cerithiid snails (*Bittium*), the amphipods (*Corophium insidiosum, Caprella geometrica, Amphithoe longimana*), and decapods (*Palaemonetes vulgaris* and *Neopanopeus texana sayi* etc.)) may result from sub-minimal light conditions for photosynthesis at the appropriate tidal levels, caused by extreme water turbidity and the virtual absence of standing water at these levels when the tide is out. Brackish pools among the *Spartina* and other salt marsh grasses near the HW level are crowded with *Gammarus mucronatus,* a small corixid water bug, and the snail *Hydrobia minuta,* with *Orchestia grillus* at the edges, and *Gammarus tigrinus* and *Corophium volutator* where fresh water seeps in. However, the ribbed mussel *Volsella demissa* (recorded by Whiteaves, 1901) and the air-breathing marsh snail *Melampus lineatus* were not found during limited search.

Certain intertidal species are extremely abundant in the Basin and Channel, much more so than along the outer Fundy shores or elsewhere in Eastern Canada. The common rock barnacle, *Balanus balanoides,* settles on all rock surfaces so completely, that in June and July the rocks appear coated with a white powder, from about 10 feet below the extreme HW line to near LW level. A similar concentration was noted at Hall's Harbour by Stephenson *et al.* (1954). The horizontal range of rocky tidal flats (one-half to three-quarters of a mile) and high proportion of intertidal to subtidal bottom (p. 3) result in a very large population of intertidal barnacles and an enormous concentration of larval stages in the Basin during the spawning season. These evidently stay mainly within the Basin during their 30-day planktonic period, and then saturate every available surface at the time of attachment. The presence of these barnacles is no doubt largely responsible for the corresponding intensity of populations of *Urosalpinx, Thais,* and other predatory whelks.

Minas Channel, on the other hand, marks the seaward limit of the Basin endemics and the landward limit of shore-dwelling invertebrates characteristic of the relatively cold salt waters of the Bay of Fundy. Among these last may be mentioned the free-swimming amphipods *Gammarellus angulosus, Pontogeneia inermis, Gammarus setosus,* and *Marinogammarus stoerensis,* the rock-clinging *Ischyrocerus anguipes,* and *Caprella septentrionalis,* and burrowing *Corophium bonelli* and *Hippomedon serratus;* the chitons *Ischnochiton ruber* and *I. albus* and several gastropods including *Lacuna vincta, Margarites* spp., *Crucibulum striatum,* and *Cingula aculeus.*

The establishment in the lower tidal zone of many deep-water bivalves and gastropods (e.g. *Astarte* spp., *Venericardia, Periploma, Nucula, Crenella, Buccinum,* and *Lora* spp.) is probably attributable to the bathymetrically uniform temperatures and to the vertical transport of larval stages by strong tidal currents. These currents are likewise responsible for casting ashore the shells of these and other deep-water species (e.g. *Placopecten, Puncturella, Balanus balanus* and *B. hameri, Colus* and *Neptunea*) on sand and gravel beaches lining the Channel.

Finally, we might note that several species taken during the course of this work are new to the Canadian Atlantic coast (e.g. *Nemopsis bachei, Corophium tuberculatum, Thais lapillus imbricata,* and *Barnea truncata*) or recorded previously in Canada only here (e.g. *Loligo pealei, Corophium volutator, Pagurus longicarpus,* and *Libinia emarginata*).

## REFERENCES

ABBOT, R. T. (1954). American seashells. Van Nostrand, Toronto, 541 pages, 40 pl., 100 fig.

BOUSFIELD, E. L. (1952). Zoological investigations in the Maritime Provinces. *In* Ann. Rept. Nat. Mus. Canada, 1950-51, Bull. 126, pp. 188-194.

———(1955a). Some physical features of the Miramichi Estuary. J. Fish Res. Bd., Canada, 12(3): 342-361.

———(1955b). Ecological control of the occurrence of barnacles in the Miramichi Estuary. Nat. Mus. Canada, Bull. 137, Biol. Ser. 46, 69 pages.

———(1956). Studies on the shore crustacea collected in eastern Nova Scotia and Newfoundland, 1954. *In* Ann. Rept. Nat. Mus. Canada, 1954-55, Bull. 142, pp. 127-152.

———(1958a). Distributional ecology of terrestrial Talitridae (Crustacea: Amphipoda) of Canada. Proc. 10th Int. Congr. of Entomology.

———(1958b). Littoral marine arthropods and mollusks from western Nova Scotia, 1956. Proc. Nova Scotia Inst. Sci. 24(3):303-325.

HUNTSMAN, A. G. (1924). Oceanography. *In* Handbook of Canada of the Brit. Assoc. Advanc. Sci., Univ. Toronto Press, pp. 274-290.

———(1952). The production of life in the Bay of Fundy. Trans., Roy. Soc. Canada., 46, III(5):15-38.

———(1958). Shubenacadie salmon. J. Fish Res. Bd., Canada. 15(6): 1213-1218.

JERMOLAJEV, E. G. (1958). Zooplankton of the Inner Bay of Fundy. J. Fish. Res. Bd., Canada. 15(6):1219-1228.

JOHANSEN, F. (1930). Marine Crustacea, Malacostraca, and Pantopoda (Pycnogonida) collected in the Gulf of St. Lawrence, Newfoundland, and the Bay of Fundy in 1919, 1922, 1923, 1925, and 1926. Can. Field-Nat. 64(4):91-94.

KETCHUM, B. H., and D. J. KEEN (1953). The exchanges of fresh and salt waters in the Bay of Fundy and in Passamaquoddy Bay. J. Fish. Res. Bd., Canada, 10(3):97-124.

KINDLE, E. M. (1916). Bottom control of marine faunas as illustrated by dredging in the Bay of Fundy. Am. J. Sci., 41:449-461.

———(1917). Notes on the bottom environment of the marine invertebrates of Western Nova Scotia. Ottawa Nat., 30:149-154.

LAROCQUE, A. (1953). Catalogue of the Recent Mollusca of Canada. Nat. Mus. Canada, Bull. 129, Biol. Ser. 44, 406 pages.

LEIM, A. H. (1924). The life history of the shad (*Alosa sapidissima* Wilson) with special reference to the factors limiting its abundance. Contrib. Can. Biol. n.s. 2(11): 163-284.

PERLEY, M. H. (1852). Reports on the sea and river fisheries of New Brunswick. 2nd Ed. Fredericton, N.B., 294 pages.

PRINCE, E. E., S. MELANSON, and S. F. MORRISON (1910). Dominion Shad Fishery Commission, 1908-10. Report and Recommendations. Ottawa, Canada. liii, 115 pages.

RATHBUN, M. J. (1929). Decapoda. *In* Canadian Atlantic Fauna. Biol. Bd., Canada, 10, 38 pages, 53 fig.

SHOEMAKER, C. R. (1947). Further notes on the amphipod genus *Corophium* from the east coast of America. J. Wash. Acad. Sci. 37(2):47-63.

———(1949). Three new species and one new variety of amphipods from the Bay of Fundy. J. Wash. Acad. Sci. 39(12):389-398.

STEPHENSON, T. A. and Anne, (1954). Life between tide-marks in North America, IIIA and IIIB. J. Ecol. 42(1):14-45; 46-70.

WALLACE, N. A. (1919). The Isopoda of the Bay of Fundy. Stud. Biol. Stations, Biol. Bd., Canada, 1, 42 pages, 12 fig.

WATSON, E. E. (1936). Mixing and residual currents in tidal waters, as illustrated in the Bay of Fundy. J. Biol. Bd., Canada 2(2): 141-208.

WHITEAVES, J. F. (1901). Catalogue of the Marine Invertebrata of Eastern Canada. Geol. Surv., Canada, Ottawa, 271 pages.

# SOME FRESHWATER FISHES FROM NORTHEASTERN QUEBEC AND LABRADOR

By D. E. McAllister and Sherman Bleakney[1]

This paper reports on eleven species of freshwater fish collected in northeastern Quebec and Labrador. These collections were made by the second author in 1952, while Carnegie Arctic scholar at McGill University. Systematic and distributional notes are included on each of the species collected.

The northern Quebec-Labrador peninsula has been poorly collected with regard to its fish fauna. Only a few recent papers concern themselves with this region. Richardson (1944) wrote on fishes of the James Bay drainages of Quebec. Legendre and Rousseau (1949) gave the distribution of specimens collected in northern Quebec. Munroe (1949) recorded several freshwater species from the Knob Lake area in northeastern Quebec. Meen (1952) commented on arctic char in Chubb and Museum lakes in northernmost Quebec. Dunbar and Hildebrand (1952) reported on the marine and freshwater species of Ungava Bay. Backus (1951 and 1957) reported on the fishes of Labrador, both freshwater and marine. Notes on freshwater fish of the Leaf Bay – Fort Chimo region were given by Bateman (1953).

The map of Quebec and Labrador, Fig. 1, shows the localities, catalogue numbers (NMC 58-. . . ), and dates of collection. The catalogue numbers are also listed under each species so that their distribution may be obtained. The listing of species under their families follows Berg (1940). Common and scientific names follow Scott (1958) and Legendre (1954). All measurements are in millimetres.

## Family Salmonidae

1. *Prosopium cylindraceum* (Pallas)
ROUND WHITEFISH
MENOMINI D'AMÉRIQUE

Collections: NMC 58-353, 2 specimens.

Standard length 174 mm, 71 mm; lateral line scales 83, *ca.* 85; dorsal rays 11, 12; anal rays 10, 10; gill rakers 17, 18. Faint parr marks apparent on both specimens. Fins unmarked.

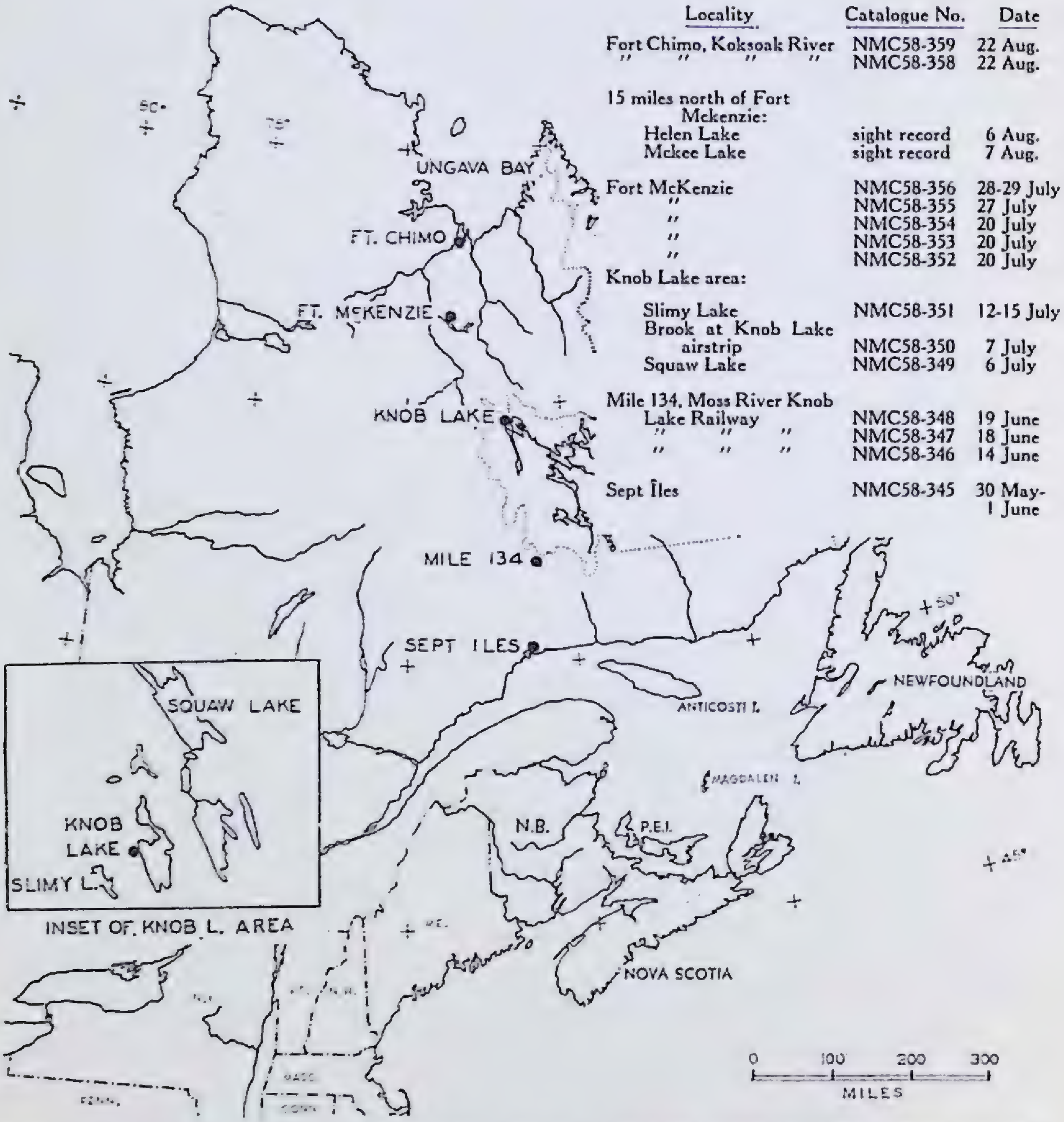
2. *Salvelinus fontinalis* (Mitchill)
BROOK TROUT
OMBLE MOUCHETTÉ

Collections: NMC 58-345, 7 specimens; NMC 58-346, 7 specimens; NMC 58-347, 7 specimens; NMC 58-351, 9 specimens; NMC 58-354, 3 specimens.

---

[1] Dept. of Biology, Acadia University, Wolfville, N.S.

All specimens with parr marks, black-spotted dorsals, white with black-backed front edge on lower fins, black-rimmed lower jaw, light spots pupil-size on sides and smaller light spots near the lateral line formerly red. Basibranchial teeth were absent in 8 specimens examined. Table 1 gives counts and measurements.



| Locality | Catalogue No. | Date |
|---|---|---|
| Fort Chimo, Koksoak River | NMC58-359 | 22 Aug. |
| " " " " | NMC58-358 | 22 Aug. |
| 15 miles north of Fort Mckenzie: | | |
| Helen Lake | sight record | 6 Aug. |
| Mckee Lake | sight record | 7 Aug. |
| Fort McKenzie | NMC58-356 | 28-29 July |
| " | NMC58-355 | 27 July |
| " | NMC58-354 | 20 July |
| " | NMC58-353 | 20 July |
| " | NMC58-352 | 20 July |
| Knob Lake area: | | |
| Slimy Lake | NMC58-351 | 12-15 July |
| Brook at Knob Lake airstrip | NMC58-350 | 7 July |
| Squaw Lake | NMC58-349 | 6 July |
| Mile 134, Moss River Knob Lake Railway | NMC58-348 | 19 June |
| " " " | NMC58-347 | 18 June |
| " " " | NMC58-346 | 14 June |
| Sept Îles | NMC58-345 | 30 May-1 June |

Figure 1. Map of Quebec and Labrador showing localities visited, catalogue numbers, and dates of collections.

Brook Trout were seen but not collected at McKee Lake and Helen Lake (both lakes 15 miles north of Fort McKenzie). The Slimy Lake specimens had insects in their stomachs, and cestodes and nematodes heavily infested the intestines. According to Legendre (1954) this fish is common throughout Quebec and Labrador.

Table 1. Counts and Measurements in *Salvelinus fontinalis*

| Catalogue No. | Standard Length | Head Length/ Standard L. | Dorsal Rays | Anal Rays | Pyloric Cacae |
|---|---|---|---|---|---|
| NMC58-345.......... | 104 | .29 | 11 | 9 | 42 |
| | 91 | .26 | 10 | 9 | 38 |
| NMC58-347.......... | 96 | .27 | 10 | 9 | 40 |
| | 95 | .27 | 11 | 9 | 39 |
| NMC58-351.......... | 159 | .25 | 10 | 9 | 42 |
| NMC58-354.......... | 127 | .26 | 11 | 9 | — |
| | 107 | .26 | 11 | 10 | — |
| | 73 | .26 | 11 | 9 | — |

3. *Salvelinus namaycush* (Walbaum)

LAKE TROUT
TOULADI

No specimens of lake trout were collected, but several were seen. At Squaw Lake (near Knob Lake) 11 were caught; at Fort McKenzie 3 were examined which contained flies in their stomachs. According to Legendre (1954), this species is found throughout Quebec and Labrador.

4. *Salmo salar* Linnaeus

ATLANTIC SALMON
SAUMON ATLANTIQUE

Three specimens were examined and photographed at the mouth of the Koksoak River, Ungava Bay, on August 12, 1952. The largest one measured 976 mm and weighed 18½ pounds. A scale sample showed it to be about 6 to 7 years of age and to have spawned twice. Oblique scale row counts (from a transparency) were approximately 121, 118, and 126. Dunbar and Hildebrand (1952) also record the Atlantic salmon from the Koksoak River; this is apparently near the extreme western limit of the species.

5. *Catostomus catostomus* (Forster)

LONGNOSE SUCKER
MEUNIER

Collections: NMC 58-347, 2 specimens; NMC 58-350, 3 specimens; NMC 58-355, 4 specimens.

Counts and measurements are given in Table 2. A count suggested by Dr. C. C. Lindsey, postanal scale rows, is included. This counts the diagonal backward-sloping scale rows starting at the anal fin origin and proceeding back to the row ending at the posterior end of the lateral line. The method saves counting all the lateral line scales to determine if the sucker is coarse or fine scaled and is much easier in small specimens where anterior scales are tiny and difficult to count. A few lateral line scale counts are included below for comparison.

TABLE 2. Counts and Measurements in *Catostomus catostomus*

| Catalogue No. | Standard Length | Postanal Scale Rows | Lateral Line Scales | Dorsal Rays |
|---|---|---|---|---|
| NMC58-347............ | 146 | 20 | 98 | 10 |
| | 35 | 18 | — | 10 |
| NMC58-350............ | 60 | 21 | c.108 | 10 |
| | 55 | 18 | — | 10 |
| | 56 | 18 | — | 10 |
| NMC58-355............ | 111 | 20 | 104 | 11 |
| | 112 | 20 | — | 10 |
| | 105 | 21 | — | 10 |
| | 101 | 19 | — | 10 |

Scale counts would indicate that this is the nominate subspecies. There are few positive records of this species in the interior of the Labrador Peninsula, although Lowe (1896) recorded two species of sucker as being common in this region. Munroe's (1949) description of the "sturgeon sucker"—small scales, bloodred stripe, and elongate head—would seem to apply to this species, although the mouth was described as whitefish-like. (That sucker and whitefish mouths are alike, Dr. W. B. Scott informs me, is a popular misconception.)

6. *Catostomus commersonii* (Lacépède)

WHITE SUCKER
CATOSTOME NOIR COMMUN

Collections: NMC 58-348, one specimen.

Standard length 98 mm, postanal scale rows 15, lateral line scales 68, gillrakers 22, dorsal rays 12. The possession of 31 predorsal scales and of a headlength/interorbital width ratio of 2.5 would indicate this form to be *C. commersonii commersonii.*

7. *Couesius plumbeus* (Agassiz)

LAKE CHUB
MENÉ DE LAC

Collections: NMC 58-350, 19 specimens; NMC 58-355, one specimen.

Table 3 gives the counts and measurements for the lake chub. The dorsal fins ranged from slightly falcate to falcate. Specimens varied from 42 to 86 mm in standard length. The ratio of eye diameter to snout was always greater than two-thirds except in NMC 58-355 where it was .64. The large eye and falcate dorsal fin would place most of the specimens in the typical subspecies. However, Lindsey (1956) has pointed out that the subspecies of lake chub are on insecure footing.

TABLE 3. Counts and Measurements in *Couesius plumbeus*

| Catalogue No. | Standard Length | Lateral Line Scales | Dorsal Ratio* |
|---|---|---|---|
| NMC58-350 | 78 | 67 | 1.6 |
| | 55 | 60 | 1.5 |
| | 56 | 67 | 1.6 |
| | 50 | 61 | 1.6 |
| | 53 | 64 | 1.5 |
| | 49 | 62 | 1.7 |
| | 53 | 61 | 1.8 |
| | 48 | 65 | 1.6 |
| | 51 | 61 | 1.5 |
| NMC58-355 | 86 | 67 | 1.4 |

Legendre and Rousseau (1949) reported the lake chub in a small tributary of the George River, 5 miles west of Indian House Lake, at long. 56°20′ N. Since then Backus (1951 and 1957) has reported the lake chub and the longnose dace (*Rhinichthys cataractae*) from Labrador at long. 53-54° N.

### Family ESOCIDAE

7. *Esox lucius* Linnaeus

NORTHERN PIKE
GRAND BROCHET

No specimens were collected, but one was seen in the Knob Lake area, at Squaw Lake. The northern pike is generally distributed in Quebec.

### Family GADIDAE

8. *Lota lota* (Linnaeus)

BURBOT
LOTTE AMÉRICAINE

Collections: NMC 58-348, one specimen.

The single specimen of burbot collected was 136 mm long. The caudal peduncle ratio (distance from notch behind second dorsal fin to the posterior end of the vertebral column, divided by the distance between the notches at the ends of the dorsal and anal fins) was 1.7. Lindsey (1956) has demonstrated clinal variation and great overlap (about 50%) between subspecies of burbot. His decision that subspecific recognition be dropped is therefore accepted.

### Family GASTEROSTEIDAE

9. *Pungitius pungitius* (Linnaeus)

NINESPINE STICKLEBACK
ÉPINOCHE À NEUF ÉPINES

Collections: NMC 58-359, 3 specimens.

---

* Dorsal ratio=length of depressed dorsal/distance from occiput to origin of dorsal.

Standard length in the three specimens was 63, 44, and 28 mm. Dorsal spines vary from IX (one specimen) to X (2 specimens). Dunbar and Hildebrand (1952) report this species as common in the Ungava Bay region, although less common than the threespine stickleback.

10. *Gasterosteus aculeatus* Linnaeus

THREESPINE STICKLEBACK
ÉPINOCHE À TROIS ÉPINES

Collections: NMC 58-356, 115 specimens.

The ten specimens examined from Fort McKenzie had 3 dorsal spines (2 free and one at front of rayed dorsal), one anal spine, and one spine and one ray in the ventral fins, and 10 pectoral rays. Table 4 gives counts and measurements. There were no keels on the caudal peduncle. This and the small number of lateral plates (*See* Table 4) indicate that this is the freshwater form. Dunbar and Hildebrand (1952) report this species to be common in Ungava Bay.

TABLE 4. Counts and Measurements on *Gasterosteus aculeatus*

| Standard Length | Head Length/ Standard L. | Body Depth/ Standard L. | Dorsal Rays | Anal Rays | Lateral Plates |
|---|---|---|---|---|---|
| 59 | .31 | .25 | 11 | 7 | 5 |
| 47 | .36 | .26 | 12 | 9 | 4 |
| 49 | .33 | .24 | 12 | 9 | 3 |
| 51 | .33 | .24 | 8* | 9 | 3 |
| 48 | .33 | .23 | 13 | 9 | 3 |
| 45 | .31 | .22 | 12 | 8 | 4 |
| 43 | .35 | .21 | 11 | 8 | 4 |
| 40 | .29 | .22 | 11 | 9 | 5 |
| 42 | .33 | .21 | 12 | 9 | 4 |
| 30 | .30 | .20 | 11 | 7 | 4 |

*injured fin

## Family COTTIDAE

11. *Cottus cognatus* Richardson

SLIMY SCULPIN
CHABOT VISQUEUX

Collections: NMC 58-349, one specimen; NMC 58-352, 6 specimens; NMC 58-358, 35 specimens.

Counts and measurements for the specimens are recorded in Table 5. The presence of palatine teeth is denoted by +, their absence by —. The last two rays of the dorsal and anal were counted as one, although in about half the fins the last two rays were on separate basals. The length of the fourth ventral ray, if present, is indicated as a fraction of the longest ventral ray.

Most of the specimens agreed with *Cottus cognatus* in lacking palatine teeth, having 3 ventral rays and a low anal count, rather than with *Cottus bairdii*, which possesses palatine teeth, 4 ventral rays, and a high anal

## Table 5. Counts and Measurements in *Cottus cognatus*

| Catalogue No. | Standard Length | Head Length/ Standard L. | Caudal Peduncle Depth/Standard L. | Palatine Teeth | Dorsal Spines | Dorsal Rays | Anal Rays | Ventral Rays | Pectoral Rays |
|---|---|---|---|---|---|---|---|---|---|
| NMC58-349....... | 45 | .31 | .074 | — | 7 | 17 | 13 | 3½ 3½ | 15 |
| NMC58-352....... | 64 | .33 | .081 | — | 8 | 15 | 11 | 3 3 | 14 |
| | 52 | .31 | .071 | — | 8 | 15 | 11 | 3½ 3 | 15 |
| | 50 | .30 | .070 | — | 8 | 16 | 10 | 3 3 | 15 |
| | 49 | .33 | .078 | — | 8 | 15 | 11 | 3 3 | 14 |
| | 48 | .29 | .067 | — | 6 | 16 | 12 | 3 3 | 14 |
| | 43 | .30 | .079 | — | 7 | 15 | 11 | 3 3 | 14 |
| NMC58-358....... | 92 | .32 | .070 | + | 9 | 16 | 11 | 3½ 3 | 14 |
| | 84 | .30 | .076 | — | 8 | 15 | 10 | 3 3 | 14 |
| | 84 | .30 | .084 | — | 8 | 15 | 11 | 3½ 3 | 14 |
| | 87 | .31 | .076 | — | 8 | 15 | 11 | 3 3 | 14 |
| | 83 | .33 | .071 | — | 8 | 16 | 12 | 3 3 | 13 |
| | 80 | .31 | .072 | — | 8 | 16 | 11 | 3 3 | 13 |
| | 70 | .29 | .073 | — | 8 | 16 | 11 | 3 3 | 13 |
| | 77 | .30 | .072 | — | 8 | 17 | 10 | 3 3 | 13 |
| | 54 | .37 | .093 | — | 8 | 16 | 10 | 3 3 | 14 |
| | 69 | .30 | .072 | +right only | 8 | 16 | 11 | 3 3 | 13 |

count. Some individuals had palatine teeth, although they were not strong. Since these specimens diverged in no other way from the others, they are also considered as *Cottus cognatus*. Robins (1954) also found occasional members of this species with palatine dentition. Unfortunately the variation in dentition makes separation of *bairdii* and *cognatus* difficult, because differences in ventral ray counts cannot be used outside of the Great Lakes area. A more detailed comparison of these two species to reveal further differences would be worthwhile.

The number of ventral rays varies geographically in *Cottus cognatus*. In the Great Lakes region, the number is usually 3. In northwestern Canada and Alaska it is usually 4, the innermost ray being about three-quarters the length of the longest. In the Columbia, Fraser, and Upper Peace rivers of British Columbia, the ventral rays are either 3 or 4. Whether the condition across the Great Plains is clinal or not requires further investigation. Examination of west coast specimens suggests a definite break, south of which rays are 3 to 4 and north of which they are constantly 4.

## ACKNOWLEDGMENTS

The authors are very grateful to Dr. W. B. Scott of the Royal Ontario Museum, and to Dr. C. C. Lindsey of the Institute of Fisheries, University of British Columbia, for critically reading the manuscript and making constructive suggestions.

## LITERATURE CITED

BACKUS, R. H. (1951). New and rare records of fishes from Labrador. Copeia (4): 288-294.

BATEMAN, B. (1953). Observations on the natural history of the Leaf Bay – Fort Chimo region, Ungava, Quebec. Intermediate Nat. (8): 1-7.

BERG, L. S. (1940). Classification of fishes. Trav. Inst. Zool. Acad. Sci. U.S.S.R., 5(2): 87-517. (Russian with English translation litho-printed 1947 by J. W. Edwards, Ann Arbor, Mich.).

DUNBAR, M. J., and H. H. HILDEBRAND (1952). Contribution to the study of the fishes of Ungava Bay. J. Fish. Res. Bd., Canada, 9 (2):83-128.

LEGENDRE, V. (1954). Les poissons d'eau douce de la province de Québec. Soc. Canad. d'Écologie, Montreal. 1:1-80.

LEGENDRE, V., and J. ROUSSEAU (1949). La distribution de quelques-uns de nos poissons dans le Québec arctique. Annales de l'A.C.F.A.S., 15: 133-135.

LINDSEY, C. C. (1956). Distribution and taxonomy of fishes in the Mackenzie drainage of British Columbia. J. Fish. Res. Bd., Canada, 13 (6): 759-789.

LIVINGSTONE, D. A. (1951). The fresh water fishes of Nova Scotia. Nova Scotian Inst. Sci., 23, pt. 1: 1-90.

LOWE, A.P. (1896). Report on explorations in the Labrador Peninsula along the East Main, Koksoak, Manicuagan, and portions of other rivers in 1892-93-94-95. Ann. Rept., Geol. Surv., Canada, 1895, new ser., No. 8, Rept. 2: 1-387.

MEEN, V. B. (1952). Solving the riddle of Chub Crater. Nat. Geog. Mag. 101 (1): 1-32.

MUNROE, E.G. (1949). Notes on fish of the interior of the Labrador Peninsula. Arctic, 2(3):165-173.

RICHARDSON, L. R. (1944). Brief record of fishes from central northern Quebec. Copeia (4):205-208.

Robins, C. R. (1954). A taxonomic revision of the *Cottus bairdi* and *C. carolinae* species groups in eastern North America. Unpub. Doctorate thesis, Cornell Univ., pp. 1-272.

Scott, W. B. (1958). A checklist of the freshwater fishes of Canada and Alaska. Roy. Ont. Mus. pp. 1-30.

Walters, V. (1955). Fishes of western Arctic America and eastern Arctic Siberia. Bull. Am. Mus. Nat. Hist. art. 5, 106:255-368.

# THE DENTITION OF RABBITS AND THE ORIGIN OF THE LAGOMORPHA

By Loris S. Russell

## Introduction

The problem of origin and systematic position of the rabbits and hares has been unsettled since Gidley (1912) argued so convincingly for their exclusion from the Rodentia and their recognition as a distinct order Lagomorpha. Simpson (1945, pp. 196, 197) summarized the evidence very well. It is a problem that calls for the consideration of all available evidence, especially that from anatomy, palæontology, and physiology. The last mentioned field of study has contributed interesting serological evidence (Moody *et al.*, 1949), which has suggested that the Lagomorpha have their nearest living relatives among the Artiodactyla. This has received some indirect support from Wood (1957), who has concluded (a) that rabbits exist, and (b) that they probably had their origin from the primitive ungulate order Condylarthra, from which the Artiodactyla most likely also originated.

The present discussion is restricted to the evidence of the teeth and is subject to limitation on that ground. It is an outgrowth of the writer's studies on the fossil teeth of Eocene and Oligocene lagomorphs. Attempts were made to reconstruct the original pattern of the cheek teeth from examples that were only slightly worn. The results of this were so interesting as to suggest that completely unworn dentitions of modern lagomorphs should be examined. No account of such dentitions could be found in the literature. The excellent paper by Dice and Dice (1941) gives a clear account of the sequence of events following eruption but does not describe or illustrate the unworn crown. No suitable specimens are present in the collection of Leporidae in the National Museum of Canada. However, in the mammal collection of the Royal Ontario Museum there are three immature skulls of *Sylvilagus floridanus* in which the cheek teeth above and below are quite unworn. For the privilege of examining and describing the dentition of these skulls the writer is indebted to Dr. R. L. Peterson of the Division of Life Sciences, Royal Ontario Museum. I shall

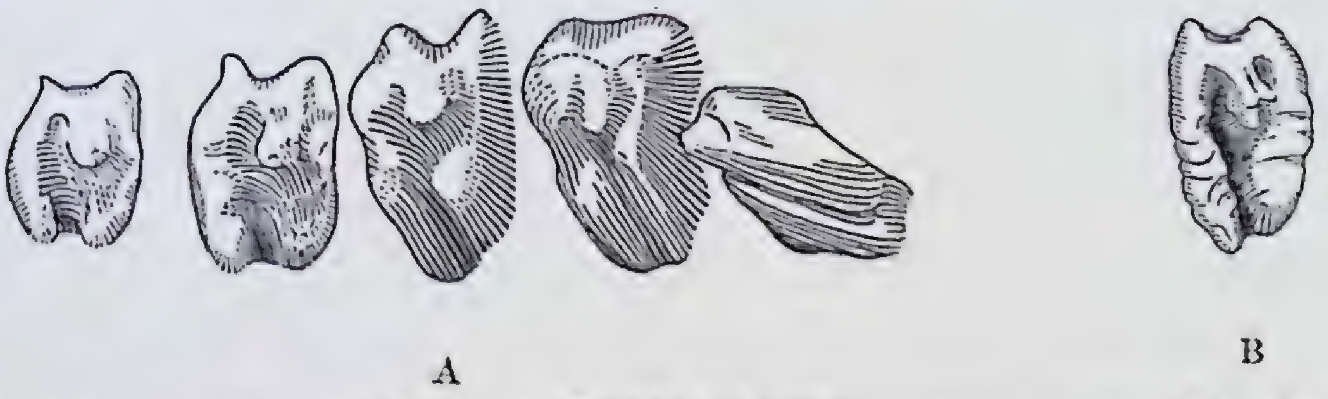


Figure 1. *Sylvilagus floridanus*, ROMZ 33.8.22.7, unworn upper right dentition, X 10: A, $DM^2$, $DM^3$, $DM^4$, $M^1$, $M^2$; B, $P^4$.

begin the discussion with an account of the worn lagomorph dentition, to be followed by a description of the unworn condition. I shall then draw comparisons with fossil cheek teeth of lagomorphs and conclude with some suggestions as to the significance of the observed structures.

## THE ADULT DENTITION

All teeth in the leporid dentition are hypsodont, that is elongate, rootless, and continuing to grow at about the same rate as they are worn away by chewing. This means that in the cheek teeth the crown view normally seen is a cross-section of the tooth. The upper cheek teeth are prismatic, but the triturating surface appears as an oval area of dentine, surrounded by an enamel wall. Except for a narrow re-entrant from the lingual side, there is nothing that could be called a crown pattern. The lower cheek teeth are each made up of two oval columns joined together, one behind the other; the anterior of the two columns is higher than the posterior. Although there is no crown pattern, the structure suggests the trigonid and talonid of lower molars in many other groups of mammals.

## THE UNWORN DENTITION

In the horse and other hypsodont mammals the pattern of the unworn dentition clearly shows the cusps and crests that made up the crown structure before the development of hypsodonty. For this reason the dentition of the three rabbit skulls in the Royal Ontario Museum is of special interest. They are numbered 33.8.22.4, 33.8.22.6, 33.8.22.7 and are identified as *Sylvilagus floridanus ?mearnsi*. The cheek dentition of each is a combination of deciduous molars and permanent molars, both sets being unworn. In the upper series (fig. 1) the dominant feature in DM, P, and M is a central cusp. This was anticipated from studies of fossil lagomorph teeth. Except in $DM^2$, this central cusp is connected to the two outer angles of the tooth by a Y-shaped crest, and the two outer arms of the Y each bear a low cusp at the terminus. From each of these two buccal cusps a crest extends linguad, forming the anterior and posterior rims, respectively, of the crown. Each of these crests terminates on the lingual margin of the crown as a prominent area, but not a true cusp. Usually the anterior crest becomes partially double at its lingual end. The lingual margin of the crown is interrupted by a broad re-entrant, separating the inner ends of the anterior and posterior crests. Traced down the lingual side of the tooth, this re-entrant becomes narrower, more compressed, so to speak, so that on worn crowns it appears as a narrow enamel crest projecting into the crown area.

The unworn lower teeth (fig. 2) show that the two parts are indeed trigonid and talonid. This is especially true of the molars. The anterior part shows clearly defined protoconid and metaconid, and even a suggestion of a paraconid. The posterior part has vestiges of the three talonid cusps—hypoconid, hypoconulid, and entoconid. Such teeth have long been recognized as primitive, the "tuberculo-sectorial" or "tribosphenic" pattern of authors. In addition to the development of hypsodonty, the lagomorph tooth has departed from the basic pattern by the partial suppression of the paraconid. A similar trend may be seen in insectivores, primates, rodents, arctocyonid creodonts, condylarths, perissodactyls, and artiodactyls.

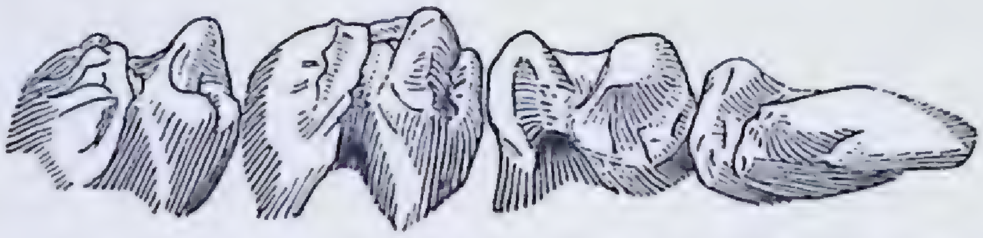


Figure 2. *Sylvilagus floridanus*, ROMZ 33.8.22.7, unworn lower right dentition, $M_2$, $M_1$, $DM_4$, $DM_3$; X 10.

### The Dentition in Fossil Leporids

Going backward in time past a number of later Tertiary leporids in which the dentition is essentially the same as that of modern rabbits, we may begin our examination of the fossil dentitions with the well-known Oligocene genus *Palaeolagus* (Wood, 1940, pp. 277–331; Dawson, 1958, pp. 19–32). Unworn and slightly worn upper molars and premolars of this genus show the conspicuous central cusp. The crest that connects this cusp with the two buccal cusps is V-shaped, rather than Y-shaped. With moderate wear the central cusp becomes isolated from the outer margin and forms a crescent-shaped or oval lake. At this stage of wear the re-entrant on the lingual margin becomes distinct, and with further wear the central lake disappears and the re-entrant takes over as the central resistant element of the crown. In *Palaeolagus* upper cheek teeth, the anterior and posterior crests are essentially the same as in the modern rabbits.

The oldest undoubted leporid is *Mytonolagus* (Burke, 1934; Wood, 1949), known from the Upper Eocene of Utah and Saskatchewan and the uppermost Eocene or lowest Oligocene of Wyoming. Upper cheek teeth in this genus differ from those of *Palaeolagus* and later leporids in being relatively compressed anteroposteriorly, that is to say, in having a more narrowly ovoid outline of crown. On unworn teeth the central cusp is distinct and has a V-shaped crest connecting it to the cusps at the buccal angles. The anterior and posterior crests and the lingual re-entrant are much as in *Palaeolagus,* allowing for the difference in crown outline.

Thus as far back as the undoubted record of the lagomorphs goes, the upper cheek teeth possessed, prior to wear, a central cusp connected by a V-shaped crest to smaller cusps at the antero- and postero-external angles of the crown.

### Possible Ancestors of the Lagomorphs

Among the fossil mammals from which the lagomorphs may have been derived, a likely ancestor is *Eurymylus* (Matthew and Granger, 1925; Wood, 1942) from the Upper Paleocene of Mongolia. Unfortunately the upper dentition in known examples of this genus is worn, and the presence or absence of the characteristic central cusp cannot be proved. However, the two buccal cusps are present, and from these cusps vestiges of a

V-shaped crest appear to extend toward the centre of the crown. On this basis the unworn crown pattern of *Eurymylus* has been restored in fig. 3B with a prominent central cusp forming the inner apex of the V-shaped crest. Note that the crown is narrowly rounded on the lingual side, in contrast to the broad and notched inner margin of the teeth in *Mytonolagus* and later leporids.

If we accept the view that *Eurymylus*, or something like it, was the Paleocene ancestor of the lagomorphs, we may go back another long step to consider the dentition in the Jurassic pantotheres. The typical upper molar of the pantotheres, such as *Melanodon* (fig. 3A) (Simpson, 1929, p.75), is a narrow tooth with prominent inner cusp, usually regarded as the protocone, and an equally prominent central or outer cusp, the undivided paracone and metacone, also called the amphicone. There are small marginal cusps on the buccal rim. From this kind of tooth the molars of many other mammalian groups can be derived in theory by broadening of the buccal margin and splitting or budding of the amphicone into distinct paracone and metacone. In zalambdodont insectivores we appear to have the amphicone in process of splitting, and the double-pointed cusp lies near the centre of the crown. It is possible that the central cusp of lagomorphs and the central cusp that was apparently present in *Eurymylus* were undivided amphicones.

## History of the Lagomorph Dentition

The various views on the origin of the cusp pattern in the cheek teeth have been summarized by Wood (1940, pp. 351-359). The most radical interpretation is that of Ehik (1926), who postulates a partial rotation. None of the views mentioned by Wood appear to take into account the evidence of the unworn teeth. This supports the idea of derivation from teeth in which the dominant feature was a central cusp, such as the amphicone of pantotheres. *Eurymylus* of the Paleocene may represent the intermediate stage between the pantotheres and the lagomorphs. It is interesting to note that in *Eurymylus* a tendency toward hypsodonty had already appeared. This may well have been the factor that arrested the splitting of the central cusp. The large internal shelf-like area was preserved as an essential part of the grinding head, for the importance of the internal cusp became much less than that of the marginal rim of enamel, a feature that could persist throughout the growth of the tooth. The effectiveness of this rim as a grinding structure was increased by its infolding on the lingual side. Vestiges of the central cusp, which persisted for some time in *Mytonolagus*, seem to have been obliterated early in *Palaeolagus*. In modern leporids it is only in the unworn dentition that this structure can be recognized.

The history of the lower molars was more like that of other mammalian groups, with the formation of a quadritubercular crown by the suppression of the paraconid. But here too the tendency toward hypsodonty arrested further development, and the cusps became evanescent features, giving way early to the enamel rim of trigonid and talonid as the important agent of trituration.

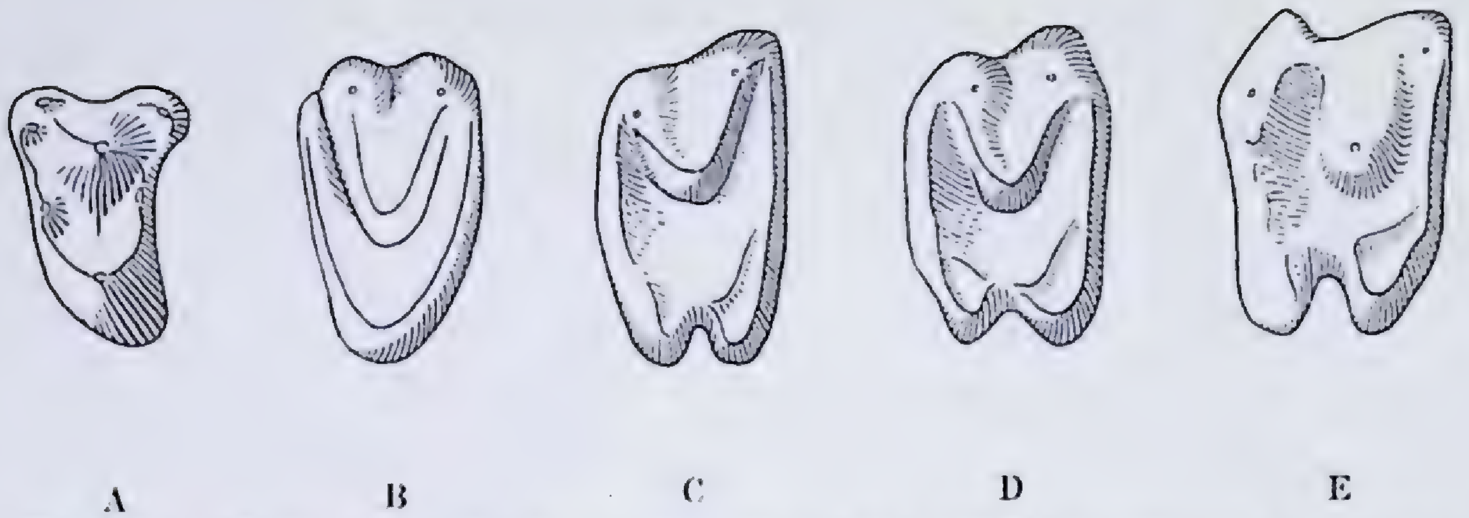


FIGURE 3. Upper right molars of lagomorphs and possibly ancestors, not drawn to scale: A, *Melanodon*, late Jurassic, after Simpson, 1929; B, *Eurymylus*, late Paleocene, modified after Matthew and Granger, 1925; C, *Mytonolagus*, late Eocene; D, *Palaeolagus*, Oligocene; E, *Sylvilagus*, Recent.

The evidence of tooth structure thus interpreted suggests that the lagomorphs were derived in late Cretaceous or early Tertiary time from a common ancestry with the zalambdodont insectivores. This occurred at a stage when the upper cheek teeth still had a single central cusp and a large but not distinctly cuspidate inner spur. In the lower molars the paraconid had become reduced, but the trigonid was still higher than the talonid. Early development of hypsodonty in the lagomorph dentition directed the evolution of the cusp pattern along different lines than that followed in the zalambdodont insectivores.

## REFERENCES

BURKE, J. J. (1934). Mytonolagus, a new leporine genus from the Unita Eocene series in Utah. Annals Carnegie Mus., Vol. 23, pp. 399-420, pl. 50.

DAWSON, Mary R. (1958). Later Tertiary Leporidae of North America. Univ. Kansas, Paleont. Contrib., Vertebrata, art. 6, 75 pages, 39 fig., 2 pl.

DICE, L. R., and DORA S. DICE (1941). Age changes in the teeth of the cottontail rabbit, Sylvilagus floridanus. Papers Mich. Acad. Sci., Arts and Letters, Vol. 26 (1940), pp. 219-228, fig. 1-8, pl. 1.

EHIK, J. (1926). The right interpretation of the cheekteeth tubercles of Titanomys. Annales Musei Nationalis Hungarici, Vol. 23, pp. 178-186, 5 fig.

GIDLEY, J. W. (1912). The lagomorphs an independent order. Science, vol. 36, pp. 285, 286.

MATTHEW, W. D., and WALTER GRANGER (1925). Fauna and correlation of the Gashato formation of Mongolia. Am. Mus. Novitates, No. 189, 12 pages, 14 fig.

MOODY, P. A., VELMA A. COCHRAN, and HELEN DRUGG (1949). Serological evidence on lagomorph relationships. Evolution, Vol. 3, No. 1, pp. 25-33, fig. 1, 2.

SIMPSON, G. G. (1929). American Mesozoic Mammalia. Mem. Peabody Mus., Yale Univ., Vol. 3, pt. 1, 235 pages, 62 fig., 32 pl.

———(1945). The principles of classification and a classification of mammals. Am. Mus. Nat. Hist., Bull., Vol. 85, 350 pages.

WOOD, A. E. (1940). Lagomorpha. *In* The mammalian fauna of the White River Oligocene. Trans. Am. Philos. Soc., n.s., Vol. 28, pt. 3, pp. 271-362, fig. 71-116, pl. 34, 35.

———(1942). Notes on the Paleocene lagomorph, Eurymylus. Am. Mus. Novitates, No. 1162, 7 pages, 7 fig.

———(1949). Small mammals from the Uppermost Eocene (Duchesnian) near Badwater, Wyoming. J. Paleont., Vol. 23, No. 5, pp. 556-565, fig. 1-24.

———(1957). What, if anything, is a rabbit? Evolution, Vol. 11, No. 4, p. 417-425, fig. 1.

# THE DISTRIBUTION OF THE BARREN-GROUND GRIZZLY BEAR IN NORTHERN CANADA

By A. W. F. Banfield

## Introduction

The barren-ground grizzly is one of the more spectacular denizens of the Canadian arctic tundra. This large, strong carnivore is well known and respected among the natives of the region. It is not surprising then that the early European explorers to the grizzly's domain recorded in their journals the appearance of bears along their routes. Samuel Hearne in 1771 was the first European to meet the species, and many accounts followed. Besides those which reported the appearance of grizzlies, some expeditions failed to meet them, and those accounts are also of interest in delineating their distribution.

In recent years the common use of aircraft for northern transportation has greatly increased the chances of observing grizzlies, many having been seen incidental to other investigations.

It is curious that an animal so easily identified by vernacular name is assigned a scientific name with difficulty. Anderson, who was a firm supporter of Merriam's (1918) classification of the bears, listed five species and subspecies of grizzlies from the Mackenzie Delta (Porsild, 1945). In addition, there are three other species listed for the area under study. Rausch (1953) applied the name *Ursus arctos richardsoni* Swainson to the barren-ground bears of the Arctic coast of Alaska. If all the barren-ground bears belong to the same variable subspecies (as is likely), that would be the appropriate name for the bears under discussion here. However, Anderson (Porsild, op. cit.) thought that there were at least two types—one short-faced and one long-faced. Fixation of names awaits a re-examination of the available specimens in the light of new concepts concerning the *Ursus arctos* complex in North America.

A comparison of the present distribution of grizzlies, based upon current observations, with the early explorers' accounts led to an impression that the distribution was expanding. A complete review of the literature was therefore undertaken, and efforts were made to collect as many recent, published and unpublished, observations as possible. In addition, the specimens in the National Museum of Canada were recorded. The information collected has been listed chronologically below with data on locality and authority. Comments have been provided in some cases for clarity.

## Chronological List of Records

1714–26—Through the courtesy of the officers of the Hudson's Bay Company, I was privileged to examine the big game references in the records of the York Factory and Churchill River posts during that period. No grizzly hides were brought in from southern Keewatin District.

1771—On July 8, 1771, Hearne (1796, p. 139) found a grizzly den in a low mound of earth (pingo?) about 125 miles southeast of the mouth of the Coppermine River, which he named Grizzled Bear Hill. In the vicinity he noted troughs dug by bears searching for ground squirrels, *Citellus undulatus*.

—On July 17, 1771, he saw the hide of an enormous grizzly at the Eskimo camp near Bloody Falls and reported that he was told they bred near by (Hearne, 1796, p. 372).

1789—Mackenzie's (1820) failure to mention grizzlies during his hurried trip down the Mackenzie River to its mouth is probably not significant.

1821—Franklin (1823, pp. 220, 334, 342, 377, 378) reported observing grizzlies on a number of occasions during his first expedition between Great Bear Lake and Bathurst Inlet—at Fort Confidence, Fairy Lake River east of the Coppermine River, Bloody Falls, Hood River, Kater Point, Bathurst Inlet, and Fort Enterprise.

1821–23—Lyon (1824, p. 175) was informed by an Eskimo from 'Noowook' (Cape Dobbs) that black bears were common in this country. It is difficult to evaluate this information: whether or not it refers to the present species. In any event it was probably a general reference to a very large area.

1834—Back (1836) in the narrative of his explorations from Fort Reliance on Great Slave Lake to the mouth of the Back River, via Artillery and Aylmer lakes, does not mention grizzlies. King (1836), who accompanied Back, also failed to mention this bear. In the preparation of the Zoological Remarks Appendix, Richardson drew from his own experience with the first Franklin expedition (Back, 1836, p. 252).

1838—Simpson (1843, p. 281), during his exploration of the Arctic coast east as far as Chantrey Inlet, observed a sow and two cubs on Barry Island, Bathurst Inlet, on August 3, 1838.

1851—Rae (1852) did not mention the species on Victoria Island.

1855—Anderson (Clarke, 1940-41) also failed to mention grizzlies on his descent of the Back River.

1864—MacFarlane (1905) met and collected grizzlies on several occasions near Fort Anderson, on the Anderson River, Lake Rendezvous, and Franklin Bay.

1879–80—Guilder (1881) does not mention grizzlies in his account of the winter trip with Schwatka from Marble Island, Hudson Bay, to Chantrey Inlet. However, Schwatka's (1885, p. 27) popular account contains several second-hand reports. The Eskimos of Simpson Strait reported meeting, on rare occasions, a grizzly-like animal during summer caribou hunts. Joe Ebierling told Schwatka that the Chesterfield Inlet Eskimos had killed some. Schwatka erroneously supposed that the American grizzlies wandered north to the Arctic Ocean during the summer and retreated to tree-line to hibernate. Considering the normal wandering of the natives and the vagueness of the reports, it is concluded that the reports refer to areas much farther west than the localities mentioned.

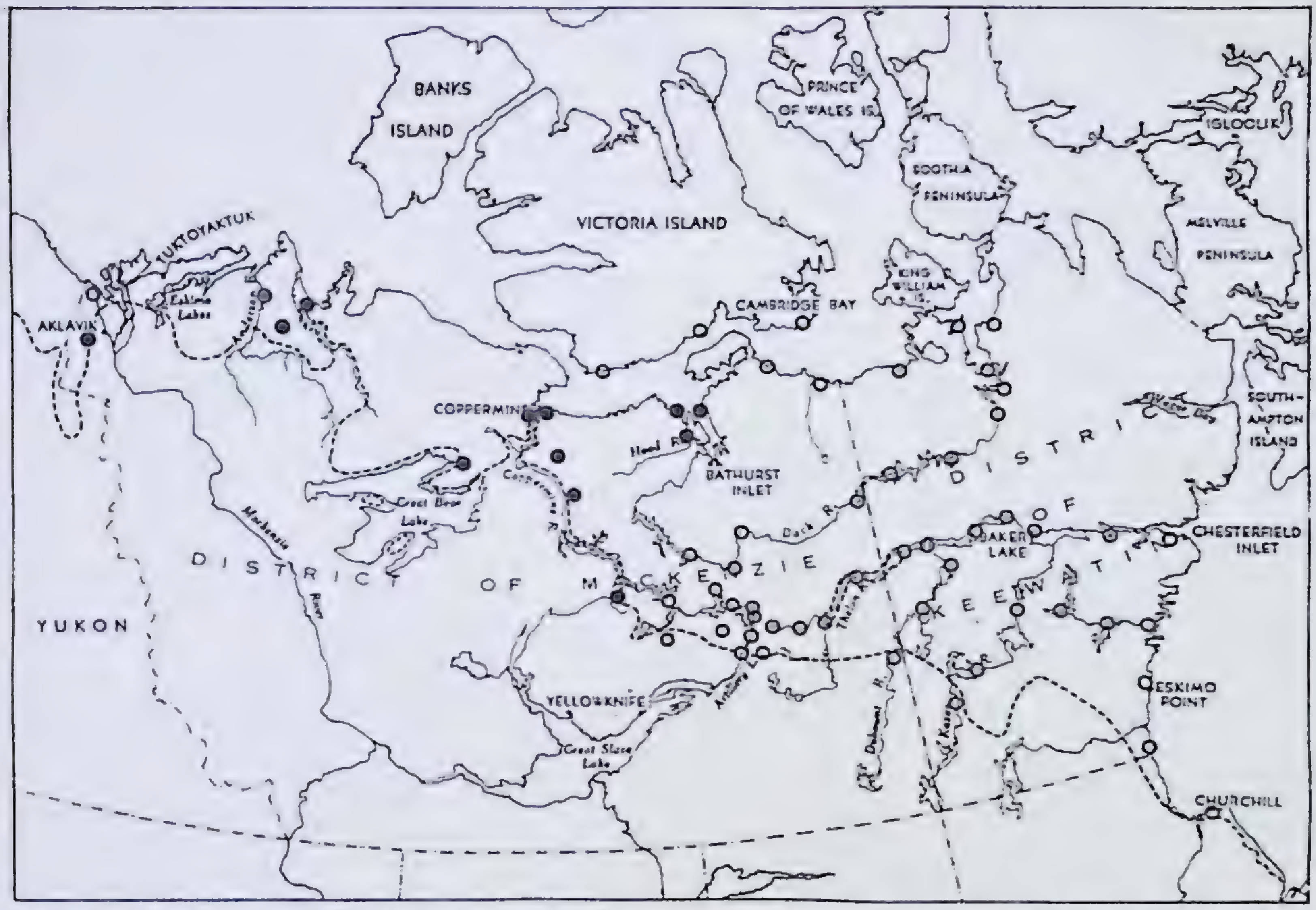


Figure 1. Barren-ground grizzly bear distribution during the period 1714 to 1899 as indicated by observations. Specimens and observations are shown by solid circles; localities visited where bears were not reported are shown by open circles. Tree-line is indicated by a broken line.

1890—Both Pike's (1892) and Mackinley's (1957) accounts of their journey from Fort Reliance to Beechey Lake via Artillery and Aylmer lakes contain no mention of grizzlies.

1893—Neither J. B. Tyrrell's (1897), nor his brother's account (J. W. Tyrrell, 1908) contain any reference to grizzlies in their accounts of the descent of the Dubawnt and Thelon Rivers to Hudson Bay.

1894—The Tyrrell brothers' field work on the Kazan and Ferguson rivers during the following season also failed to produce any signs of grizzlies (Tyrrell, 1897).

1894—Russell (1898) collected a specimen west of the Mackenzie Delta, on June 28, 1894. He reported the range as extending east to Bathurst Inlet. He also mentioned he had examined hundreds of skins which showed great variation.

1894—Munn (1932) undertook a summer trip east of Artillery Lake and later that year an autumn trip north of Artillery Lake. He did not mention the species.

1895—Whitney (1896) undertook a spring muskox hunt from Fort Reliance northward to MacKay Lake, and possibly as far as Lac de Gras, but failed to meet a grizzly. He wrote that there was a barren-ground bear exhibited in the Smithsonian Institution as coming from the barren grounds, but he believed it to be wrongly accredited: such bears inhabited the Anderson River to the northwest.

1897–8—'Buffalo' Jones also visited the tundra regions east of Great Slave Lake on a muskox hunt (Inman, 1899). He described travels in the Artillery Lake, Clinton-Colden Lake, and Hanbury River areas, perhaps even reaching Thelon junction, without mentioning grizzlies.

1899—Hanbury (1902) ascended the Thelon and Hanbury rivers from Baker Lake. He mentioned black bears in the Thelon valley but made no mention of grizzlies.

1900—The first record of a grizzly in the Thelon valley was obtained by Tyrrell (1902, p. 27). Bear tracks were twice observed on the descent of the Thelon River in July, and Mr. Fairchild shot a small silver grey specimen on the return trip.

1900—Dr. J. M. Bell, of the Geological Survey of Canada, wrote to E.A. Preble (in litt.) that he "saw grizzly bears, large greyish-brown brutes, quite often along the west and north shore of Great Bear Lake."

1900—Preble (1902) obtained no information during his trip to Eskimo Point.

1901—The next year Preble (1905) obtained some information on these bears in the Great Bear Lake area. He obtained the claws from one reported to have been killed near the mouth of the Mackenzie River. The Indians told him that many bears were found on Grizzly Bear Mountain west of McVicar Arm and, less frequently, near the outlet of the lake. Peter McCallum also reported that the region of the Scented Grass Mountains was also a favourite haunt of the species.

1902—Hanbury (1902) met an Eskimo at the junction of the Back and Buchanan rivers, who told him that grizzlies were very rare and that he had never seen one himself. Hanbury continued on to the Arctic coast and then west to Great Bear Lake. The Ogden Bay natives reported bears as rare along the coast. Hanbury saw tracks and signs from Kent Peninsula to Coppermine. The last fresh tracks were seen near the Haldane River, Great Bear Lake.

1907—Seton (1911) failed to find any sign of grizzlies during his summer trip through Artillery, Clinton-Colden, and Aylmer lakes.

1910–12—Anderson in Stefansson (1913, pp. 519–521) reported the centre of grizzly abundance was about Langdon Bay and on the lower Horton River. Specimens were taken at Langdon Bay and Cape Lyon and on the Dease River, east of Great Bear Lake. A few were met in the Coppermine area, but they were rare in the Coronation Gulf region. Eskimos reported that they were absent from Victoria Island.

1912—Douglas did not encounter them during his journey from Great Bear Lake to the Coppermine River.

1912—Wheeler (1914) killed a grizzly near Fort Enterprise.

1915–20—The National Museum of Canada contains a series of grizzly bear specimens taken during the Canadian Arctic Expedition, led by V. Stefansson, from the following localities: Stapylton Bay, Rae River, Coronation Gulf, Arctic Sound, Dease River, Hood River, Bernard Harbour, Coppermine River, and Dolphin and Union Straits.

1921–24—No definite information on grizzly bears in Keewatin District was obtained by the Fifth Thule expedition. Degerbøl and Freuchen (1935, p. 101) do not mention the grizzly but reported that black bears (?Eskimo–"akdla") occurred south of Baker Lake and Eskimo point.

1924–25—Critchell-Bullock (1930–31) failed to see any grizzlies during his trip from Great Slave Lake to Baker Lake.

1924—However, Blanchet (1924–25) reported observing signs of grizzlies on his journey from Great Slave Lake to the source of the Coppermine River via MacKay and Outram Lakes.

1925—Hoare (1927, 1930) did not record any grizzly observations, but Clarke (1940) reported Hoare once having seen more than twenty at Inman River, Bathurst Inlet.

1927–28—Porsild (1945) reported that bears were common in the Richardson Mountains, Mackenzie Delta, and Eskimo Lakes during his stay in the area.

1929—The National Museum contains a specimen taken by C. B. Dawson northeast of Great Slave Lake.

1930—G. H. Blanchet collected a specimen at the mouth of the Coppermine River, which is in the National Museum of Canada.

1930—Jerome Catholique shot one at Artillery Lake (Clarke, 1940, pp. 33-34).

1930—Ingstad (1933) travelled from Nonacho Lake to Lynx Lake and the Thelon River but did not encounter the grizzly.

1930—Porsild (MS.) failed to observe the species on his descent of the Kazan River.

1931–34—Porsild (1945) reported that the species was still common in the Richardson Mountains, Mackenzie Delta, and Eskimo Lakes, during his second stay in the area. He collected six specimens locally.

1934—Alan Stewart saw several in the vicinity of Aylmer and Muskox Lakes (Clarke, loc. cit.).

1935—A specimen collected by George Magrum at Outram Lakes is in the National Museum of Canada.

1937—One was traded at Fort Rae by an Indian (Clarke, loc. cit.).

1937—Royal Canadian Mounted Police reported a grizzly killed at Contwoyto Lake (Clarke, loc. cit.).

1937—Clarke and Hoare saw tracks along the shore of the Hanbury River at Dickson Canyon and at Grassy Island on the Thelon River. The Eskimos at Beverly Lake had shot a sow and her cubs just prior to July 17, 1937.

1938—Gavin (1945) reported that a pair of grizzlies were encountered on the sea-ice, 15 miles west of Perry River, in March, 1938. One was shot and skinned by the Eskimos. That was the only local record during his four years at the post.

1939—Downes (1943) does not mention the species in connection with his trip to Nueltin Lake.

1940—R.C.M. Police detachment at Baker Lake reported that a barren-ground bear was observed on the lower Thelon River east of Schultz Lake on July 23, 1940. Another was seen west of Beverly Lake on the same patrol.

1940—Manning (1943) collected data on the distribution of mammals along the northwest coast of Hudson Bay. He referred Lyon's (op. cit.) record of black bear to the present species and further stated that grizzlies, although rare, were seen west of Wager Bay. At Manning's suggestion I corresponded with W. E. Brown, Hudson's Bay Company, who was formerly stationed at Wager Bay, but he (pers. comm.) had no information on grizzlies in that area. Since those reports are based upon hearsay alone, it is concluded that they refer to areas much farther west.

1942—Carnegie Museum possesses two specimens from the Mackenzie Delta (Porsild, 1945).

1942–44—Clarke (1944) reported these bears as common in the Mackenzie Delta and Anderson River areas. He observed signs at Tuktoyaktuk and Paulutuk. The National Museum contains skulls from Richards Island collected in 1939 and 1941.

1945—Manning (1948) reported on wildlife conditions at nineteen summer stations in northern Manitoba and southern Keewatin District but did not mention grizzly bears.

1947—Harper (1956) did not find any evidence of them about Nueltin Lake.

1948–49—Banfield (1951) reported observing one bear near the source of the Tree River and skins at an Eskimo camp at Contwoyto Lake. Lawrie (MS.) did not encounter bears at Angikuni or Beverly lakes in Keewatin District.

1949—Hanson *et al.* did not mention the species in their list of Perry River mammals.

1950–51—Kelsall (MS.) observed a grizzly 20 miles inland from Bathurst Inlet post, in June 1951. He also collected a specimen taken near Bathurst Inlet in 1950. He later saw tracks on the shores of the Thelon River.

1951–52—Manning and MacPherson (1958) reported the taking of a grizzly bear in the Masik River Valley, Banks Island, by a Banks Island Eskimo. This is the first report of a grizzly from one of the Canadian Arctic Islands.

1952—Tener (MS.) observed an adult bear on August 18, 1952, on the banks of the Thelon River, 15 miles above Beverly Lake. He also saw tracks at Grassy Isle, Hornby Bend, and at the mouth of the Finnie River.

1953—Robert H. Smith, U. S. Fish and Wildlife Service, while conducting waterfowl surveys, observed grizzlies at the east end of Beverly Lake on July 19. On July 22, he saw one at Grays Harbour. He has observed them on numerous occasions since 1948. Foci of abundance appeared to be between the Mackenzie and Anderson Rivers and in the Thelon valley. None were observed in the Back River valley (pers. comm.).

1953—Gunderson, Breckenridge, and Jarosz (1955) found no evidence of grizzlies near Lake MacDougall on the lower Back River.

1954—Ellis (1957) failed to encounter the species during field investigations at a number of coastal stations: Stapylton Bay, Coppermine, Read Island, Cambridge Bay, Gjoa Haven, Perry River, Spence Bay, Pelly Bay, and Igloolik.

1953–56—The R. C. M. Police annual game reports, prepared by northern detachments, contain a few important records of grizzly bears which are pertinent to the present paper. These have been extracted below. Spence Bay detachment reports contain no evidence of grizzlies from 1952 to 1956. Grizzly bears were reported in the Carcajou Mountains north of Fort Good Hope in 1954. One was reported killed north of Arctic Red River. Grizzlies were reported to be quite numerous about Baker Lake in the early autumn of 1952. They seemed to disappear in mid-November. One was observed at Schultz Lake during the summer of 1952, and another near Beverly Lake during the summer of 1955. However, none were seen on a patrol up the Dubawnt River. Bears were reported to be on the increase near Tuktoyaktuk in 1953. Two bears were observed on the east side of the Coppermine River big bend in January 1956. Three bears were seen at the Dismal Lakes in June 1956.

1955—Tener (MS.) observed four bears at Lookout Point on the Thelon River, but none on the Back River during canoe trips in those areas.

1957–58—A large number of bears have been observed during the course of the intensive co-operative barren-ground caribou investigation (Kelsall and Loughrey, MS.). This was due partly to the great amount of survey flying and partly to the summer activity centred in the

Thelon River region. The following observations were listed: a sow and a cub, Clark River, June 11, 1957 (Kelsall, MS.); two bears, Mosquito Lake, June 4, 1957; three bears on June 11, at the same locality; two bears at Beverly Lake, June 28, and again on July 3; one bear, Spruce Grove Lake, July 9; three bears, Wharton Lake, July 18, and four bears east of Thelon River, August 18.

1958—Alan G. Loughrey donated to the National Museum three skulls from Aylmer Lake, Beaverhill Lake, and Nicholson Lake (Dubawnt River), which were secured from predator control operations in the spring of 1958.

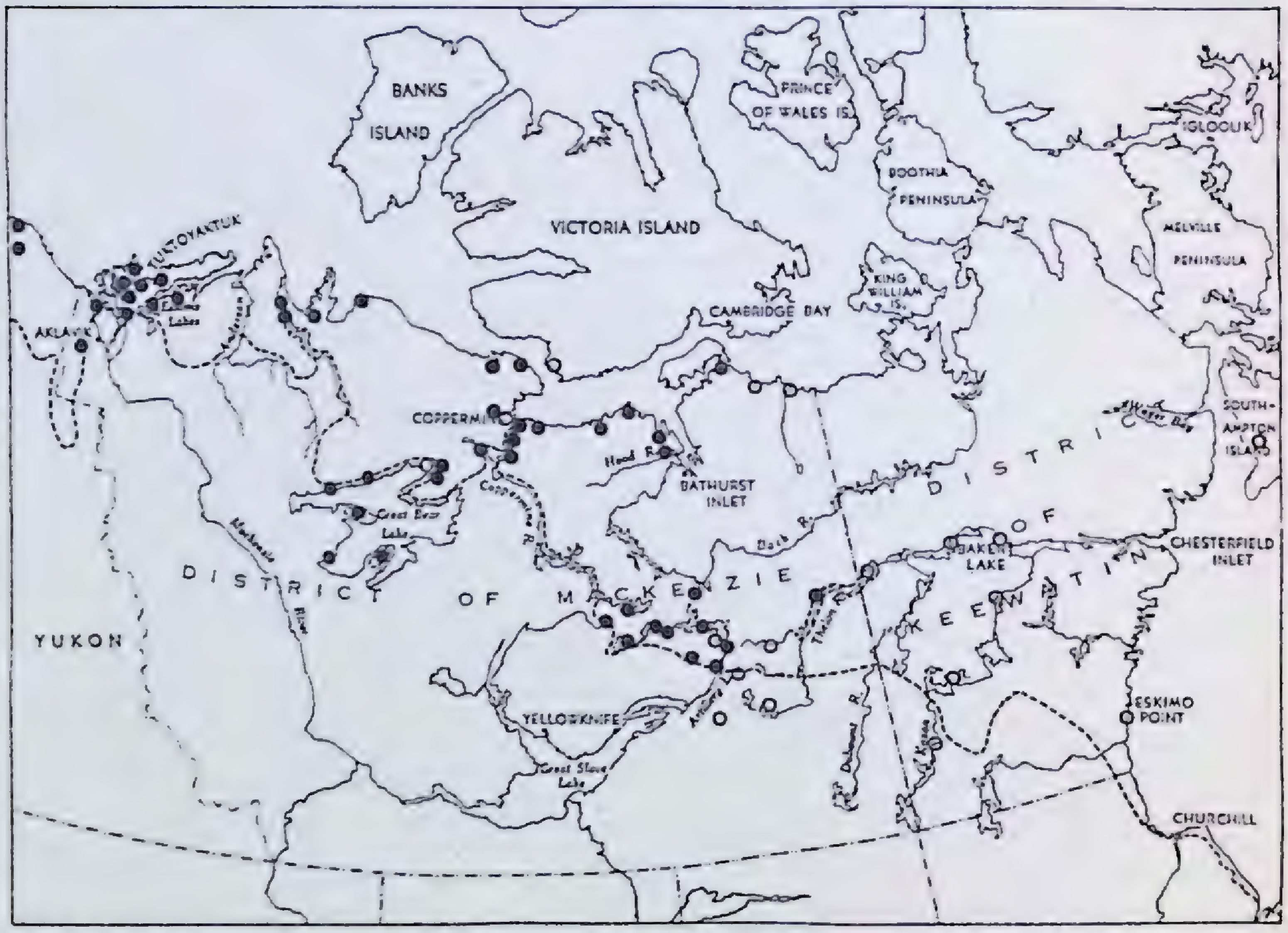


Figure 2. Barren-ground grizzly bear distribution during the period 1900 to 1935, as indicated by observations. The symbols are the same as in Figure 1.

## Discussion

The reported observations of the barren-ground grizzly bear by Europeans, voyageurs, and natives may generally be accepted with confidence. In many cases specimens were collected to substantiate the records. In other cases the observations, or lack of observations, were corroborated by the accounts of other members of the party. On the other hand I rejected a few records which were based upon hearsay and probable misinterpretation of native reports.

The previously listed observations have been plotted on a series of base maps for the following periods: prior to 1900, 1900–1935, and since 1935, in figures 1, 2, and 3. The gradual eastern dispersal of the bears since 1900 is evident from an examination of the figures. Indeed the spread southeast from the Thelon River seems to have accelerated in the past decade. The capture of one bear on Banks Island in 1951–52 suggests that they may disperse on the Canadian Arctic Islands if the climate continues to ameliorate.

There are two generalizations which may be made concerning the barren-ground grizzly range. In the first place, they appear to prefer the tundra habitat. When observed in the taiga, it is generally near tree-line. Secondly, they share that habitat with their chief prey, the arctic ground squirrel (*Citellus undulatus*). The present distribution of bears crosses the Mackenzie Delta and extends eastward across the tundra from the vicinity of timber line to the arctic coast, without any connection to the south.

It is obvious that the occupation of this area is geologically quite recent, since that region was covered by the Wisconsin Ice-cap until approximately 7,500 years ago. The ice-cap gradually melted back eastward toward its Keewatin centre, and the tundra vegetation followed it. It is therefore concluded that the present dispersal is a post-Wisconsin extension from the 'Beringia' refugium in Alaska and western Yukon.

Ground squirrels form an important item in the bears' diet, particularly in the autumn just prior to the bears' hibernation and again in the early spring, soon after the bears have emerged and before new vegetation and ground-nesting birds are available. It is probable that the bears could not live where ground squirrels are absent. It is therefore interesting to note that the range of the ground squirrels extends eastward to Hudson Bay and north to Boothia and Melville peninsulas. It appears that bears are following their prey eastward, although lagging perhaps by a few centuries.

From time to time fears have been expressed concerning the status of the barren-ground grizzly. In 1947, the Northwest Territories Game Regulations provided a closed season for the bears. Since that date grizzlies appear to have increased in numbers, particularly along the arctic coast in the Anderson and Horton River valleys, Bathurst Inlet, and the Thelon River area. They remain rare in the Mackenzie Delta area where they are hunted by the reindeer herders. Elsewhere, native utilization is light, and there seems to be no cause for anxiety concerning their current status. It is encouraging to note that the effect of civilization has been negligible and that the bears are permitted to disperse naturally.

There have been a number of vague references (Anon., 1953) to the occurrence of grizzly bears in northern Quebec and Labrador. Elton (1954) reviewed the historical accounts and accepted several references as evidence of the former occurrence of grizzlies in the Ungava peninsula, particularly in the Torngat Mountains. In the absence of specimens, recognition of the Ungava grizzly rests upon the descriptions by traders and missionaries of the rare grey, grizzled or brown bear hides brought in by the natives.

There are several factors that should be considered before those observations are accepted uncritically. Because of the fierce disposition attributed to the grizzly bear (*Ursus arctos horribilis*), its fame spread far beyond its range. The Ungava trader John McLean was familiar with grizzlies in British Columbia. However, his speculations concerning its Canadian distribution and the distinctive coloration of bears (Elton, op. cit.; pp. 345-346) have proved to be incorrect.

Because of the great variability in pelage colour of grizzly and black bears (*Ursus americanus*), the identification of bear hides is not always easy. There are also seasonal changes in pelage and claws to consider. Indeed the trenchant differences are in skull and body characteristics.

Since Eskimo rely upon game resources for their sustenance, they are familiar with the arctic and subarctic fauna far beyond their own hunting grounds. For instance, Eskimo hunters of Ungava are familiar with the muskox (Omingmuk), even though it does not occur in their domain. They could quite as easily describe "Aklak," the barren-ground grizzly, to a European inquirer.

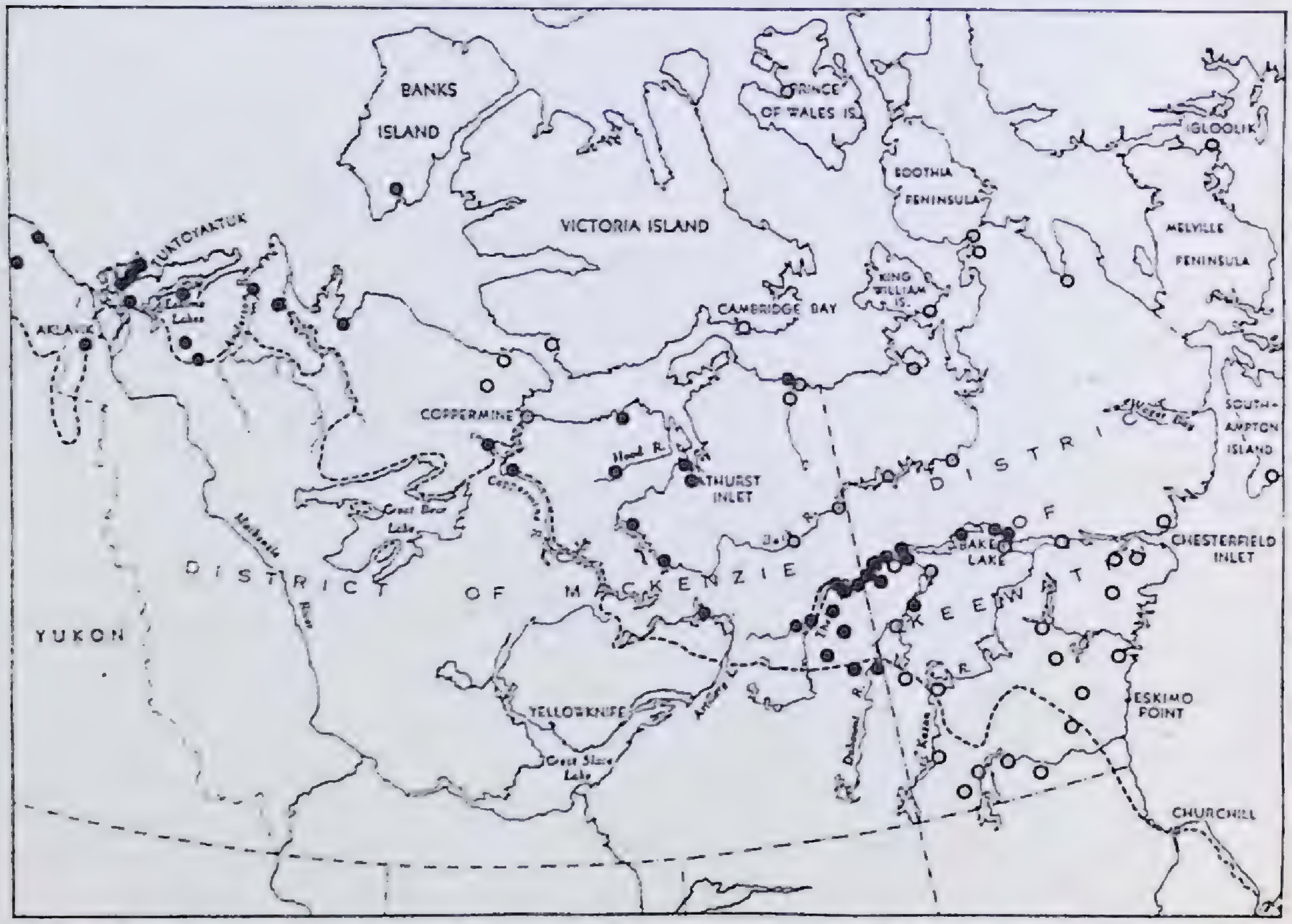


Figure 3. Barren-ground grizzly bear distribution during the period 1936 to 1958, as indicated by observations. The symbols are the same as in Figure 1.

It is even possible that through trading, some grizzly hides might have reached Ungava natives. For how else can one account for the choice of Labrador as the type locality for the American badger (*Taxidea taxus* Schreber=*Meles labradorius* Gmelin), based upon skins reaching Europe through the fur trade.

Considering the distribution of *Ursus arctos horribilis* in the great plains and Cordilleran regions, and the present restricted distribution of the barren-ground grizzly, it seems unlikely that an isolated form could occur in Ungava. Such a subspecies would have had to migrate northward after the retreating Wisconsin Ice-cap from a refuge in southeastern North America without leaving a trace.

Extensive aerial surveys in Ungava, including the Torngat Mountains in 1954 and 1955, and local inquiries failed to produce any evidence of grizzlies (Banfield and Tener, 1958), although black bears were commonly observed along the George River.

As a final consideration, it should be noted that ground squirrels of the genus *Citellus* do not occur in the Ungava region.

## CONCLUSIONS

Barren-ground grizzlies (*Ursus arctos richardsoni* Swainson) are dispersing eastward across the tundra of Mackenzie and Keewatin districts. The migration seems to be a natural post-Wisconsin glaciation dispersal from the 'Beringia' refugium of the lower Yukon Valley. The supposed occurrence of the grizzly bear in Ungava is incompatible with the present distribution pattern of the species in North America.

## ACKNOWLEDGMENTS

I wish to acknowledge the co-operation of the Chief of the Canadian Wildlife Service, the Commissioner of the R. C. M. Police, and the Hudson's Bay Company, for permission to use unpublished data on their files. I should also like to acknowledge the assistance of Dr. C. H. D. Clarke, who independently came to the same conclusions concerning grizzly distribution.

## REFERENCES

ANDERSON, R. M. (1913). Report on the natural history collections of the expedition. *In* V. Stefansson. My life with the Eskimo. New York, Macmillan Co., pp. 519-522.

ANON. (1953). Expedition to Ungava, summer 1953. Arctic, 6(4):277-278.

BACK, G. (1836). Narrative of the arctic land expedition to the mouth of the Great Fish River and along the shores of the Arctic Ocean, in the years 1833, 1834, and 1835. London, J. Murray. 663 pages.

BANFIELD, A. W. F. (1951). Notes on the mammals of the Mackenzie District, Northwest Territories. Arctic, 4(2):112-121.

BANFIELD, A. W. F., and J. S. TENER. (1958). A preliminary study of the Ungava caribou. J. Mamm., 39(4):560-573.

BLANCHET, G. H. (1924-25). An exploration into the northern plains north and east of Great Slave Lake, including the source of the Coppermine River. Can. Field-Nat., 38:183-187; 39:12-16, 30-34, 52-54.

CLARKE, C. H. D. (1940). A biological investigation of the Thelon Game Sanctuary. Nat. Mus. Canada, Bull. No. 96, Biol. Ser. 25, 135 pages.

———(1940-41). Chief Factor James Anderson's Back River Journal of 1855. Can. Field-Nat., 54(5):63-67, (6)84-89, (7)107-109, (8)125-126, (9)134-136; 55(1):9-11, (2)21-26, (3)38-44.

———(1944). Notes on the status and distribution of certain mammals and birds in the Mackenzie River and western Arctic area in 1942 and 1943. Can. Field-Nat., 58(3):97-103.

CRITCHELL-BULLOCK, J. C. (1930-31). An expedition to subarctic Canada. Can. Field-Nat., 44:53-59, 81-87, 111-117, 140-145, 156-162, 187-196, 207-213; 45:11-18, 31-35.

Degerbol, M., and P. Freuchen (1935). Mammals. Report of Fifth Thule Expedition 1921-24. 2(4-5), 278 pages. Copenhagen, Gyldendalske Boghandel, Nordisk Forlag.

Douglas, G. M. (1914). Lands forlorn; a story of an expedition to Hearne's Coppermine River. New York, G. P. Putnam's Sons. 285 pages.

Downes, P. G. (1943). Sleeping Island, the story of one man's travels in the great barren lands of the Canadian north. New York, Coward-McCann, Inc. 296 pages.

Ellis, Derek (1957). Some observations on the mammals in the area between Coppermine and Pond Inlet, N.W.T. during 1954 and 1955. Can. Field-Nat., 71(1):1-6.

Elton, C. S. (1954). Further evidence about the barren-ground grizzly bear in northeast Labrador and Quebec. J. Mamm., 35(3):345-357.

Franklin, Sir John (1823). Narrative of a journey to the shores of the Polar Sea in the years 1819, 20, 21, and 22. Zoological Appendix: Mammals and Birds by Joseph Sabine. London, J. Murray. 768 pages.

Gavin, A. (1945). Notes on the mammals observed in the Perry River district, Queen Maud Sea. J. Mamm., 26(3):226-230.

Gilder, W. H. (1881). Schwatka's search: sledging in the Arctic in quest of the Franklin records. New York, C. Scribner's Sons. 316 pages.

Gunderson, H. L., W. J. Breckenridge, and J. A. Jarosz (1955). Mammal observations at lower Back River, Northwest Territories, Canada. J. Mamm., 36(2):254-259.

Hanbury, D. T. (1904). Sport and travel in the northland of Canada. London, E. Arnold. 319 pages.

Hanson, H. C., Paul Queneau, and Peter Scott (1956). The geography, birds and mammals of the Perry River region. Arctic Inst. North Am. Spec. Pub. No. 3, 96 pages.

Harper, F. (1956). The mammals of Keewatin. Mus. Nat. Hist. Univ. of Kansas, Misc. Pub. 12, 94 pages.

Hearne, S. (1796). A journey from Prince of Wales's Fort, in Hudson's Bay to the northern ocean, etc. in the years 1769, 1770, 1771, and 1772. London. 485 pages.

Hoare, W. H. B. (1927). Report of investigations affecting Eskimos and wild life, District of Mackenzie. Dept. of Interior, Ottawa, 44 pages. Mimeo.

———(1930). Conserving Canada's Musk-oxen. Dept. Interior, Ottawa, 53 pages.

Hornby, J. (1934). Wildlife in the Thelon River area, Northwest Territories. Can. Field-Nat., 48(7):105-111.

Ingstad, Helge (1933). The land of feast and famine. New York, Alfred Knopf. 332 pages.

Inman, H. (1899). Buffalo Jones Forty Years of Adventure. Topeka, Kansas; Crane & Co. 469 pages.

Kelsall, J. P. (MS.). Report on caribou calving studies, 1951. Can. Wildlife Serv., Ottawa. 24 pages.

———(MS.). Biological investigations north of Great Bear Lake, 1953. Canadian Wildlife Serv., Ottawa. 24 pages.

———(MS.). The barren-ground caribou co-operative investigation: report No. 1, Can. Wildlife Serv., Ottawa. 12 pages.

———, and A. G. Loughrey (MS.). The barren-ground caribou co-operative investigation: Report No. 2, Can. Wildlife Serv., Ottawa. 48 pages.

King, R. (1836). Narrative of a journey to the shores of the Arctic Ocean in 1833, 1834, and 1835, under the command of Capt. Back, R.N. London. R. Bentley, 1, 312 pages; 2, 321 pages.

Lawrie, A. H. (MS). Itinerary of Keewatin part barren-ground caribou survey, 1948-49. Can. Wildlife Serv., Ottawa. 71 pages.

Lyon, G. F. (1824). The private journal of Captain G. F. Lyon of H.M.S. *Hecla* during the recent voyage of discovery under Captain Parry. London, John Murray. 468 pages.

MacFarlane, R. (1905). Notes on the mammals collected and observed in the nothern Mackenzie River district, Northwest Territories of Canada, with remarks on explorers and explorations of the far north. Proc. U. S. Nat. Mus., 28:673-764.

MACKENZIE, A. (1802). Voyages from Montreal on the River St. Laurence, through the Continent of North America to the Frozen and Pacific Oceans in the years 1789 and 1793. London. 412 pages.

MACKINLAY, J. (1957). Journal of Fish River exploring party. Arctic Circular 10 (3/4):1-70.

MANNING T. H. (1942). Remarks on the physiography, Eskimo, and mammals of Southampton Island, Can. Geog. J., 24:17-33.

———(1943). Notes on the coastal districts of the eastern barren grounds and Melville Peninsula, from Igloolik to Cape Fullerton. Can. Geog. J., 26(2):84-105.

———(1948). Notes on the country, birds, and mammals west of Hudson Bay between Reindeer and Baker Lakes. Can. Field-Nat., 62(1):1-28.

———, and A. H. MACPHERSON (1958). The mammals of Banks Island. Arctic Inst. North Am. Tech. Paper No. 2, 74 pages.

MACPHERSON, A. H., and T. H. MANNING (MS). The birds and mammals of the Adelaide Peninsula, N. W. T. Nat. Mus. Canada, Bull. 161, Biol. Ser. 59 (in press).

MERRIAM, C. H. (1918). Review of the grizzly and big brown bears of North America (genus *Ursus*) with description of a new genus *Vetularctos*. North Am. Fauna No. 41, 136 pages.

MUNN, H. T. (1932). Prairie trails and Arctic by-ways. London. Hurst and Blackett. 288 pages.

PIKE, WARBURTON (1892). The barren ground of northern Canada. London, Macmillan Co. 300 pages.

PORSILD, A. E. (MS.). Report of a trip through Keewatin. Dept. of Interior, Ottawa, 48 pages MS.

———(1945). Mammals of the Mackenzie Delta. Can. Field-Nat., 59(1):4-22.

PREBLE, E. A. (1902). A biological investigation of the Hudson Bay Region. North Am. Fauna, No. 22. 140 pages.

———(1908). A biological investigation of the Athabasca-Mackenzie region. North Am. Fauna, No. 27, 574 pages.

RAE, J. (1852). Recent explorations along the south and east coasts of Victoria Land. J. Roy. Geog. Soc., 22:82-96.

RAUSCH, ROBERT (1953). On the status of some Arctic mammals. Arctic, 6(2):91-148.

RUSSELL, F. (1898). Explorations in the far north, etc. Iowa City, Univ. Iowa Press. 290 pages.

SCHWATKA, F. (1885). Nimrod in the north or hunting and fishing adventures in the Arctic regions. New York, Cassell Co. 198 pages.

SETON, E. T. (1911). The Arctic Prairies. New York, Int. Univ. Press. 308 pages.

SIMPSON, T. (1843). Narrative of the discoveries on the north coast of America; effected by the officers of the Hudson's Bay Company during the years 1836-39. London, R. Bentley. 419 pages.

SUTTON, G. M., and W. J. HAMILTON, JR. (1932). The mammals of Southampton Island. Memoirs of the Carnegie Mus. 12, pt. 2, sect. 1, 111 pages.

TENER, J. S. (MS). Report of the musk-oxen study Thelon Game Sanctuary, 1952. 3 pages MS.

TYRRELL, J. B. (1897). Report on the Doobaunt, Kazan and Ferguson Rivers and the northwest coast of Hudson Bay. Ann. Rept. (New Series) Geol. Surv. Canada, 9:1F-218F.

TYRRELL, J. W. (1902). Report of an exploring survey between Great Slave Lake and Hudson Bay, Districts of Mackenzie and Keewatin. Ann. Rept., Dept. Int. 1902, Ottawa, Reprint 1924, 38 pages.

———(1908). Across the Sub-arctics of Canada. Toronto, Ryerson Press. 280 pages.

WHITNEY, CASPAR (1896). On snow-shoes to the barren-grounds: twenty-eight hundred miles after musk-oxen and wood-bison. London, Osgood McIlvaine Co. 324 pages.